A Customizable Fuzzy Expert System for Regional and Local Play Analysis

Final Report

for the period

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ABSTRACT

The objective of this project was to create a user definable and customizable fuzzy expert system tool to dramatically speed local and regional play analysis and to reduce subsequent drilling risk. This general tool would not have required significant knowledge of computer programming, and had design goals of guiding users through the process of building a successful expert system to evaluate plays from field to basin scale using public and/or private data and their own or public data and knowledge. To demonstrate the effectiveness of the tool, a secondary objective of analyzing the Pennsylvanian play of southeastern New Mexico was intended. Public data was organized for an analysis of this outstanding, bypassed-pay play, which was to provide an example of the usage of the system while simultaneously providing a significant opportunity for identifying new reserves. While final software development was ruled out in the revised SOPO, shortening the project to 2 years based on budget constraints, this geologic database provides a worthwhile result and should provide use to anyone interested in the play.

Four major tasks were deemed necessary in order to accomplish the project goals. Task 1 was the development of a customizable fuzzy expert system (CFS), with the ability to self-generate software and fully customize integral components of the expert system for non-computer programmers. Task 1 was fully completed. Task 2 was the development of interfaces to simplify the goals of Task 1. The creation of wizards to aid in the work flow process makes expert system development both quicker and easier. Task 2 was not completed as the project ended before software could be developed and tested with the Pennsylvanian dataset. Task 3 had two main components concerning the development of data and knowledge about the Pennsylvanian carbonate play of SE New Mexico, an excellent bypassed pay opportunity. Task 3.1 was fully completed with development of a comprehensive geologic database and associated rules. Task 3.2 was to have intertwined the testing and final software development with a CFS analysis of the Pennsylvanian. This task was removed in the modified SOPO. An ongoing effort in Tech Transfer comprised Task 4, as the ultimate test of the successful program will require that it is

widely available and utilized. The project generated 8 papers/presentations and graduated 2 M.S. students during its two year duration.

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EXECUTIVE SUMMARY

The objective of this project was to create a user-definable and -customizable fuzzy expert system tool to dramatically speed local and regional play analysis and to reduce subsequent drilling risk. Two particular challenges for this general tool is that it must not require computer programming skill, and that it will instead use software wizards and highly adaptable software subsystems to guide users through the process of building a successful expert system to evaluate plays from field to basin scale using public and/or private data and their own or public expertise. To demonstrate the effectiveness of the tool, an analysis of the Pennsylvanian play of SE New Mexico, a play with significant potential for bypassed pay, was selected as a test case during the design and testing phases of the system.

In the first project year a large set of rules that form default settings based on play type and dimensions was gathered using the Delphi method. These rules were used to populate databases with rules, variables, and fuzzy sets that can be defined or redefined on demand. Preliminary software that allowed customization using a graphical interface to add, subtract or modify rules based on those of the user was also developed. A prototype of the scalable and adaptable inference engine was completed, and the initial data for an outstanding, bypassed-pay play, the Pennsylvanian play in New Mexico, were collected.

In the second project year work continued on making fuzzy sets and rules scalable and easily configured, as well as self-checking for conflicts and consistency. Software development resulted in a prototype of the CFS system which is currently under in-house testing (alpha testing) of software components, evaluation of the efficiency of the integration of software components, and in production of preliminary expert systems. The software is ready to be tested and modified by a small group of future users (beta testing); this was scheduled for the third project year. Completion of data collection for the Pennsylvanian play, including organization of maps and data for testing of the CFS software at the end of year 2, was to have allowed generation of an example of the usage of the system, while simultaneously providing a significant opportunity for identifying new reserves. The database as it stands is a significant resource for Explorationists.

Report Details

Introduction

Four major tasks were accomplished to complete the modified project goals (SOPO revised May 2007 to reflect a Reduced Budget, see Appendix I). Progress on these four tasks comprise the remainder of this report

Task 1.0: Development of a customizable fuzzy expert system (CFS) with the ability to self-generate software and fully customize integral components of the expert system for non-computer programmers. Core software was developed, though the final user friendly version was removed from the SOPO and not completed

Task 2.0: Development of graphical user interfaces and wizards to simplify the goals of Task 1.0 by using wizards that allow users to quickly and easily build and customize the system. This task was largely removed in the modified SOPO.

Task 3.0: Data and rule collection from the Pennsylvanian Carbonate play of southeastern New Mexico and subsequent validation of the utility of the system. Data was fully collected and rules were developed. The testing of the Pennsylvanian was removed in the modified SOPO.

Task 4.0: A continuous effort in tech transfer, as the ultimate test of the successful program will require that it is widely available and utilized.

The Gantt chart shown in Fig. 1.0 gives the approximate time distribution of the tasks and some of the major subtasks discussed below. Tasks 1, 3 and 4 were active during the first year, while the second year of the project saw the development of Task 2 and the completion of Task 3. No year three tasks were accomplished as the project was modified to 2 years due to lack of funding.

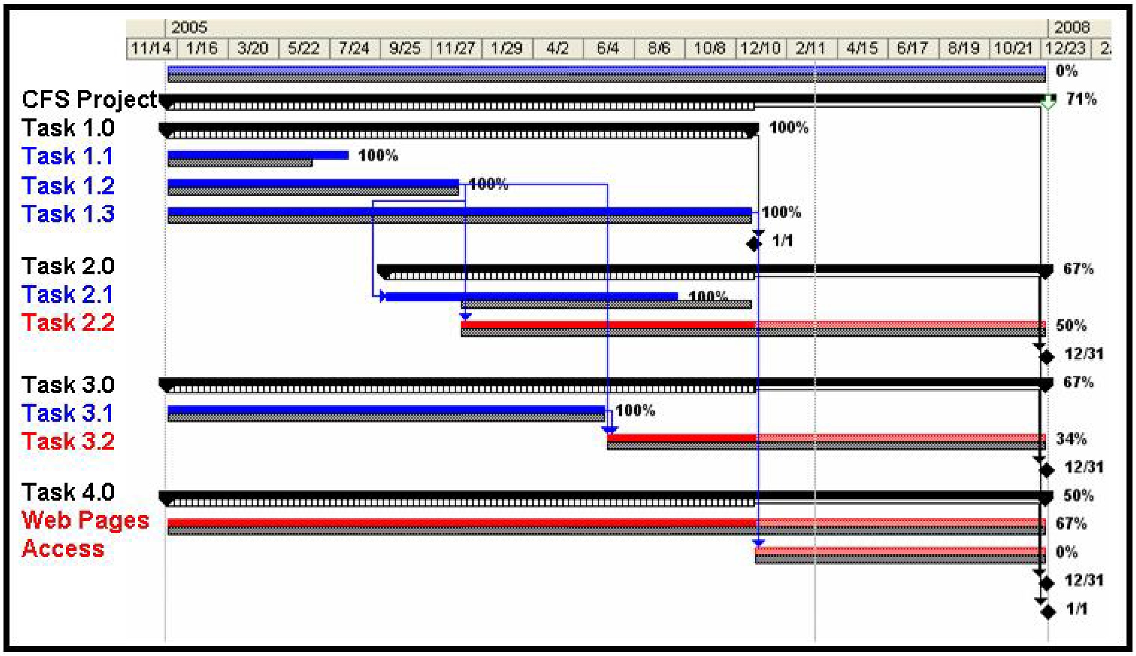


Fig. 1.0. Gantt chart of project tasks.

1. Task 1: Expert System Development

The primary goal of Task 1 was to create a CFS that can quickly and easily adapt to exploration problems in a wide range of settings, with little–to-significant user input and modifications as required. Task 1 is divided into three main subtasks: creating a generalized knowledgebase, creating databases and self-generating software, and building the generalized fuzzy inference engine.

Generalized Knowledgebase

On project inception work immediately began on the development of the generalized knowledgebase. The generalized knowledgebase represents a basic core of knowledge in the form of rules that subsets can be drawn from to represent any generalized play type. The first step was to develop a method of gaining data through questionnaires and interviews. Acting as the first "expert" to be interviewed, Co-PI Ron Broadhead defined the three major types of plays the expert system should address: stratigraphic sandstone, stratigraphic carbonate, and structural plays. He further separated each play type into developed fields and wildcat drilling. Previous work had provided a basic set of rules for structural plays (the Devonian carbonates) and stratigraphic sandstone plays (Lower Brushy Canyon); therefore initial work began on collecting data for a stratigraphic carbonate play (Upper Pennsylvanian) while concurrently refining and generalizing the play specific rules from the previous work. Most plays in the region can be generally categorized as one of these three play types.

To build a series of knowledgebases for these broad play types required the use of knowledge management techniques. The Delphi method, first developed in the 1960s as a forecasting tool by the Rand Institute [Hillier and Lieberman, 1966 and Foutz, 2001] is a proven approach. In this iterative method, expert panelists are sent a questionnaire with relevant questions related to their exploration methods. The results of this questionnaire are then analyzed and used to develop a second questionnaire. The second questionnaire, along with the aggregate results of the first questionnaire, is sent back to the participants. The results of this questionnaire then form the foundation of the knowledgebase. This method has been used to build the knowledgebase for a number of modern expert systems [Foutz, 2001, Exsys, 2004].

A sample group of experts was interviewed in Roswell, NM and Midland, TX in order to design and build the first circulated questionnaires. This initial questionnaire, representing 18 core questions and the three major play types, was mailed to a list of 304 persons at companies that have shown interest in the previous FEE Tool project. At the same time, a flier with a link to an online survey was mailed to 1683 people with experience in Permian Basin prospecting. The results from these questionnaires were then summarized into a draft, which was sent to a smaller group of experts for review. The reviewed draft became the basis for the preliminary knowledgebase.

By the middle of the first project year, the preliminary knowledgebase was finalized for each of six categories, with each category made up of a formation type and prospect type as described above. There are three formation types and two prospect types. The formation types were structural, stratigraphic carbonate and stratigraphic sandstone and the prospect types were developed field and wildcat. Based on the results of the in-person interviews and mailed questionnaires, a set of rules ranked in order of relevance were developed for the six resulting categories.

Each of the six generalized knowledgebases was then expanded to include the mathematical rules in both a crisp and fuzzy format. The example below is of a flag rule set in both crisp and fuzzy formats. The complete sets of rules, along with a table with the weighing coefficients for the six knowledgebases were presented in the First Annual Report as an appendix [Balch, 2005].

<u>What is the estimated porosity at the prospect location?</u>

Crisp rules:

- If $0 < \varphi \leq 5\%$ then flag = -1
- If $5\% < \varphi \leq 10\%$ then flag = 0
- If $10\% < \varphi \leq 15\%$ then flag = 0.5
- If $15\% < \varphi \leq 20\%$ then flag = 1
- If $20\% < \varphi \leq 25\%$ then flag = 1.5
- If $\varphi > 25\%$ then flag = 2

Fuzzy rules:

If φ is low then flag = degrade
If φ is average then flag = no change
If φ is slightly high then flag = slightly enhance
If φ is high then flag = enhance
If φ is very high then flag = strongly enhance
If φ is extremely high then flag = very strongly degrade

Equations 2.1 and 2.2 show how the rules are used to determine a final (crisp) estimate for a prospect.

$$F = \sum_{i=1}^{15} n_i f_i \quad \text{……………………………………………………………………} 2.1$$

n_i: scaling factors that serve to rank the rules in the order of importance as given by the experts
f_i: output from the ith flag rule (a positive value of f_i enhances the location's potential, a negative value degrades it)

If F ≥ 0, then
$$final\ \ estimate = \sqrt[1+F]{initial\ estimate} \quad \text{…………………………………………………} 2.2$$
If F < 0, then
$$final\ estimate = initial\ estimate^{(1+|F|)}$$

With the knowledgebases complete, sample data was generated to serve as inputs, and a fuzzy expert system and crisp model expert system were designed and built. This data was used for initial validation of the CFS inference engine.

Databases and Self-Generating Software

The previous successful expert systems for exploration (the Delaware and Devonian FEE Tools) were coded in the Java programming language by the same group of researchers as this project. This system uses a more dynamic design than these earlier systems, allowing users to enter their own rules (knowledge) and/or modify existing rules and parameters for defining the associated fuzzy ranges. This has been accomplished by storing rules, variables and fuzzy set parameters in database files that are called by Java classes. In other words, the software accesses databases, determine the number and types of rules and variables, and then self-implements software to address the requirements. Similarly, fuzzy sets are dynamically configurable to fit any needed distribution that a rule requires. The final goal was to allow explorationists using the software to perform jobs previously requiring significant programming expertise. This job was not completed under the new SOPO; however the core software functionality does exist.

The design of basic architecture has been finalized and development of prototypes to test functionality of key software components has been completed. This prototype software consists of three major software design and implementation tasks:

1. Interface definition and interface generator
2. Fuzzy variable / rule definition and fuzzy inference algorithm
3. Data management

The *interface definition and interface generator* is a tool that aids users in determining what questions and data are required by their customized expert systems. It has been tested by using it to re-create the Delaware FEE Tool.. Figure 1.1 shows a screenshot from an early implementation of this tool.

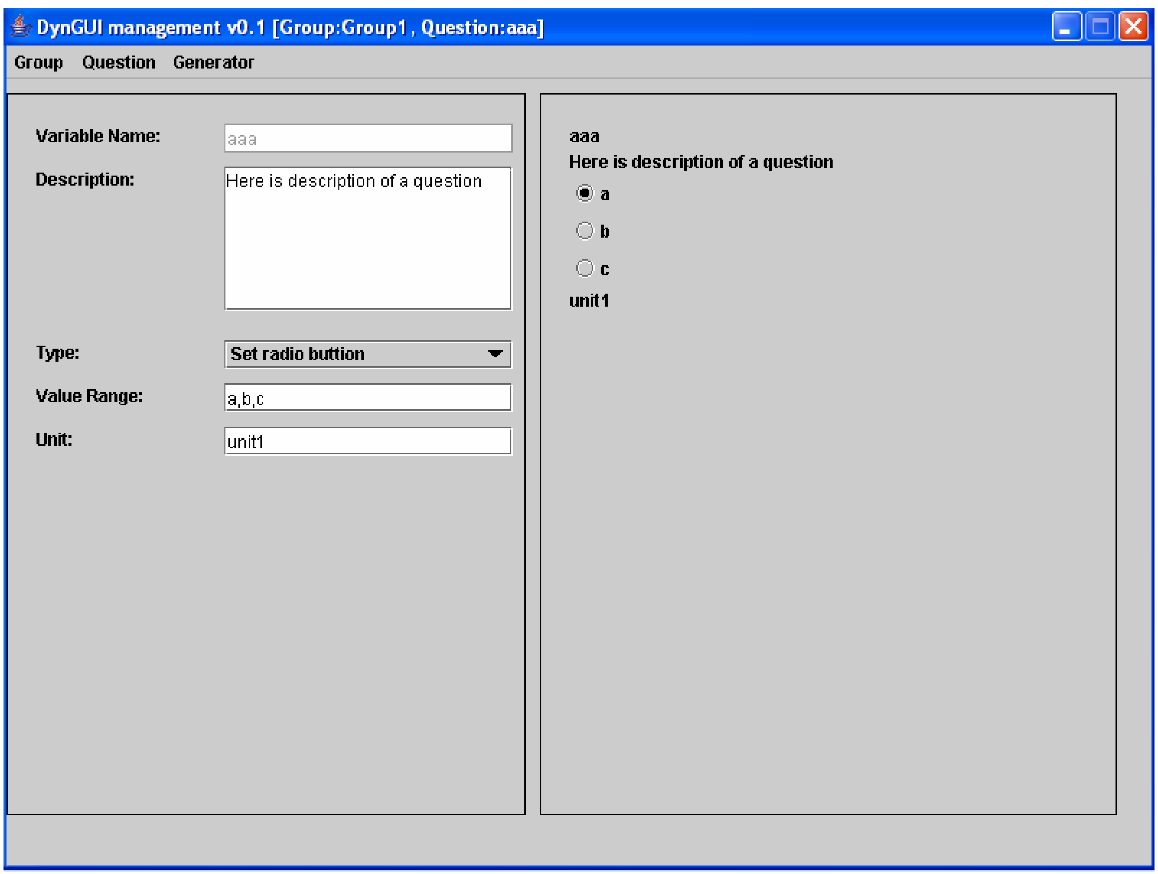


Fig. 1.1. Screenshot of the interface generator tool showing a screen where the user can define a question to be used in the interface.

The *fuzzy rule definition* function was coded and evaluated for functionality. This component allows the user to define fuzzy rules based on defined fuzzy variables and fuzzy sets. This tool works with either fuzzy sets from the preliminary knowledgebases, or with the user's raw data in combination with the statistical analysis tool described below. Figure 1.2 is a screen capture of this tool.

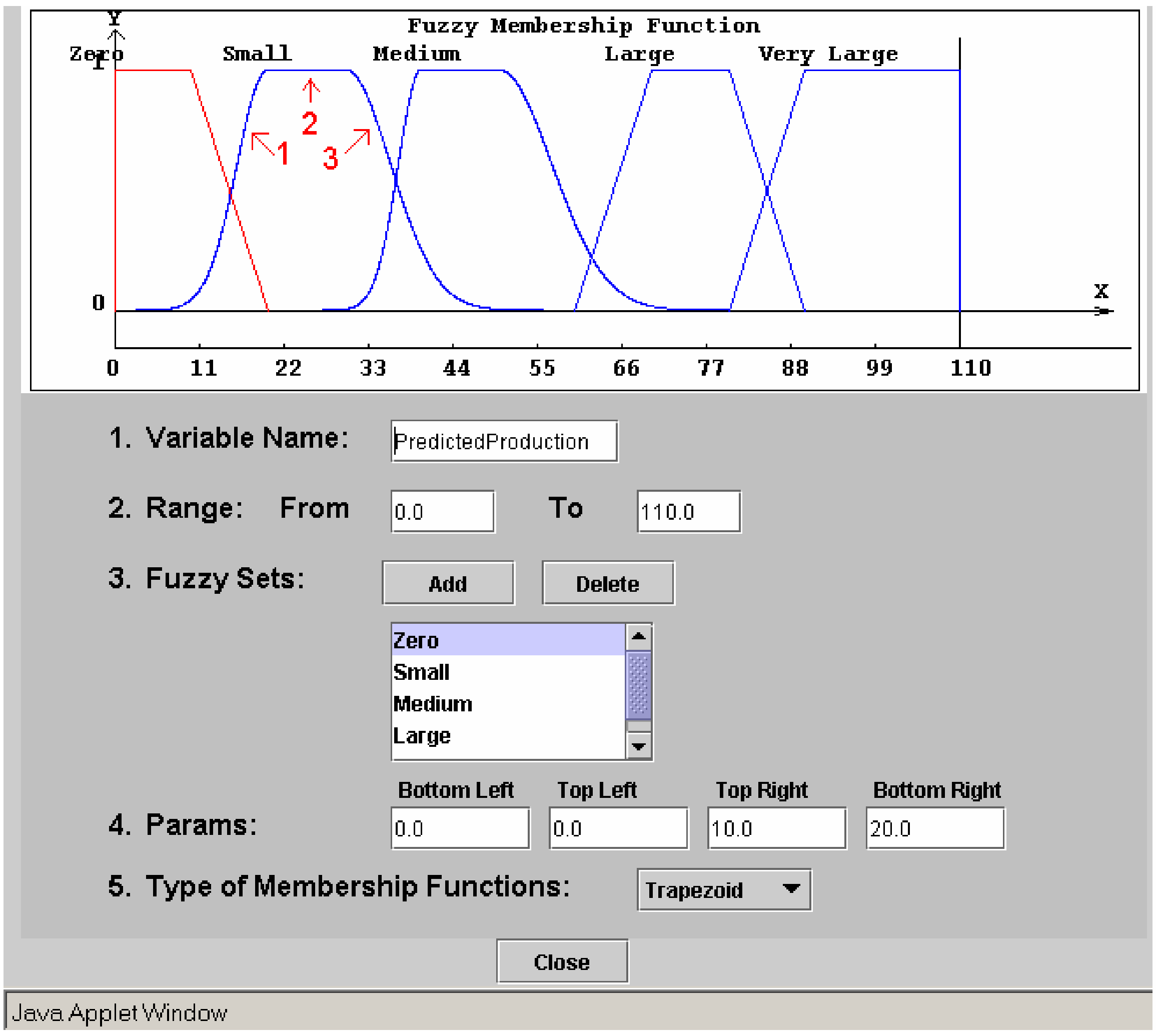


Fig. 1.2. This is an example of the fuzzy rule definition software. The user may view and modify pre-defined fuzzy curves by changing the shape, adding or deleting curves, and adjusting parameters arrows indicate portions of the curves that can be manually adjusted by clicking and dragging with a mouse.

The *data management* design implements a tree-based menu, which will provide the structure of the main menu of the final customizable fuzzy expert system. The prototype software has been designed, coded and verified. File access functions for data management of user data in Excel, binary, and text formats were subsequently coded. Figure 1.3 is a screen capture of the basic interface of the first prototype system showing the CFS-generated replica of the Delaware FEE Tool.

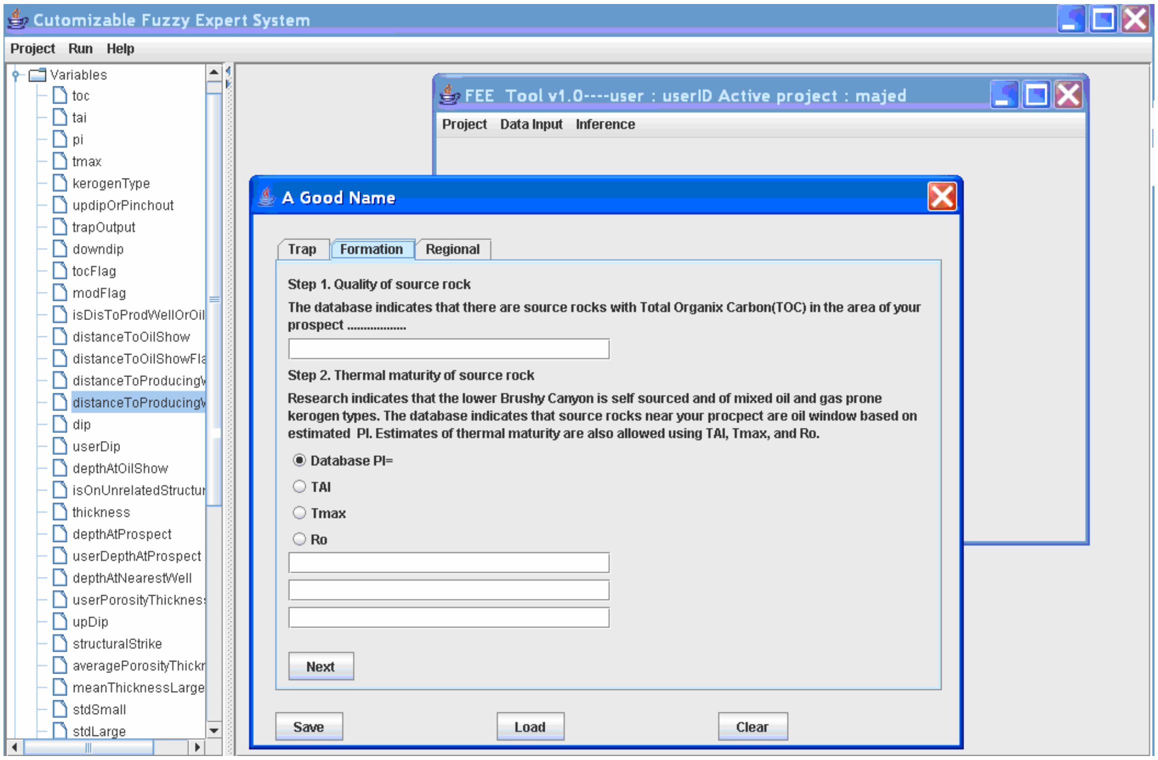


Fig. 1.3. An example of the new CFS question editing tool using a rule for stratigraphic formations.

The knowledgebases were designed to coordinate with the two other components. In order to allow the knowledgebase rules to be used as a starting point by the question definition/interface generator, a description of the structure of the rule and the type of input it required was added to each rule set in the knowledgebase. Types of input include numerical input (e.g. oil price, water saturation, distance to nearest producing well), categorical input (e.g. input for dip angle rules could be from the set of {strongly updip, updip, same elevation, downdip, strongly downdip}), and yes/no input (e.g. rules that involve using a gravity anomaly map to determine if gravity supports structure). The user can currently view, modify, add to, or delete the basic knowledgebase rules through the question definition/interface generator.

Generalized Fuzzy Inference Engine

The generalized inference engine requires the ability to access the rule and fuzzy set data stored in databases. At the core of the system, the inference engine organizes the rules, checks for conflicts and outputs a resulting interpretation, in this case, an estimate of how successful a prospect will be. A fuzzy inference engine is not dependent on large amounts of specific data and can perform inference with scarce data with properly formed questions. The challenge for developing this inference engine was allowing a large number of variables and ranges to be defined by the user. The software needed to adapt to each study based on an analysis of rules, variables, and fuzzy ranges described and stored in external database files that can and will be changed on demand by users.

This subtask required the first two project years and its development during the second year was linked with the database classes developed for subtask 1.2 in order to allow seamless integration of data and rules.

Building on the success of the first year prototype tests, a functional version of the software has been completed and has been integrated with user interfaces. It is anticipated that only minor changes to inference software will be required, as the Pennsylvanian data is processed using the CFS software. The prototype has been used to replicate the results of the Delaware FEE Tool by giving it access to the data already generated for that play. Specifics on design and testing of the inference engine were reported in the first annual report.

In the third quarter of the first year, analyses of the working prototype of the core software susbsytems were initiated. This early version of the core software was not user-friendly; it was primarily designed to allow testing of components and to verify that calculations are being made correctly. The prototype also allowed the determination whether any substantially important inputs, data types, and previously not considered tools needed to be designed for the success of the project. The prototype was used to replicate the results of the Delaware FEE Tool by giving it access to the data already generated for that play. Ideally a cross-plot of the inference results between the Delaware FEE Tool and the prototype should be identical at the order of the significant figures of the data used in the calculations, and essentially plot a line. Since the new inference engine was designed from the ground up with a modular design philosophy that differed from the original code, it was important to verify that it functioned as specified. Comparison of the two results allowed us to identify a number of bugs, which were subsequently rectified.. Examination of the cross-plot in Fig. 1.4 shows that most of the 60,478 points are identical, with only a few significant outliers. Examination of the outliers allowed the two inference engines to be fully reconciled. The current state of the new inference engine is equivalent to the earlier FEE Tool inference engines, but with much more flexibility

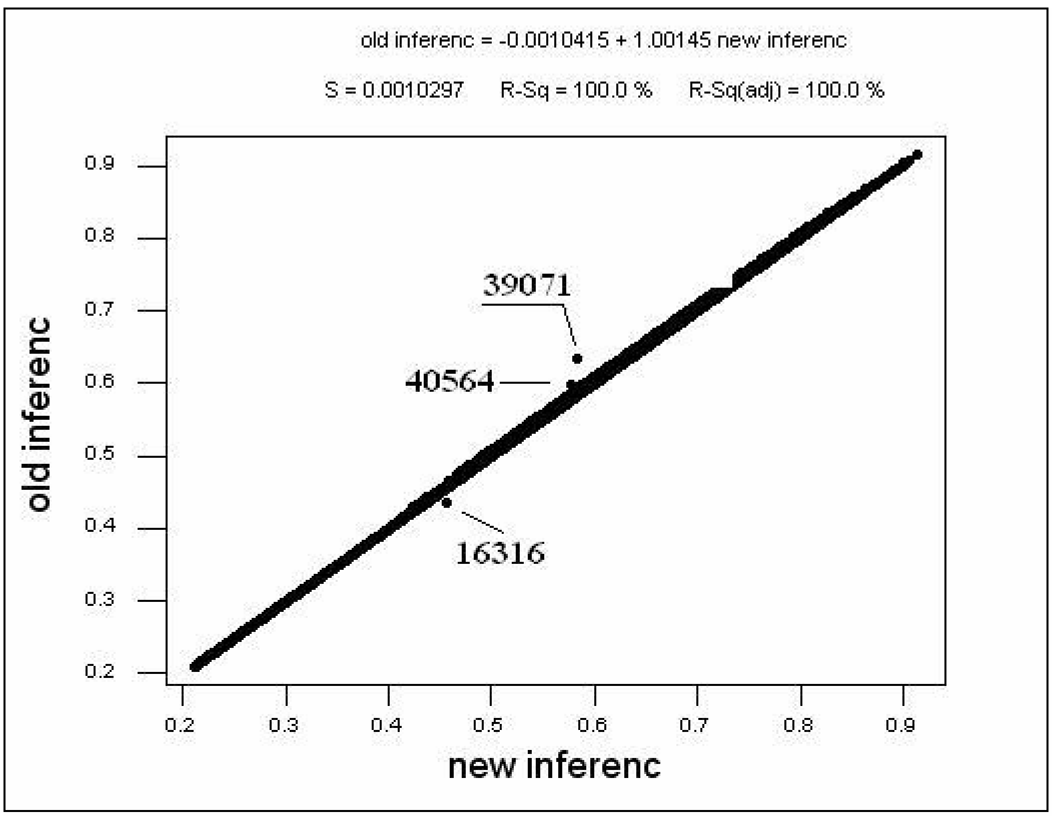


Fig. 1.4. Comparison of the Delaware Basin results using the FEE Tool and the prototype CFS Tool.

With the CFS interface engine correctly reproducing FEE Tool results, work began on developing the code to run the CFS using the six generalized knowledgebases and a synthetic data set containing 100 input values for each of the rule sets. Concurrently, a crisp model of the CFS expert system was also developed using the same test data sets and the crisp versions of the knowledgebase rules. Having both the crisp and fuzzy models developed into complete test sets allowed for a variety of validation testing. After the first round of testing, improvements and corrections were made. The following figures (Figs. 1.5 – 1.10) are scatter plots showing the relationship between the CFS and the crisp models. While by design the fuzzy datasets will provide scatter, these plots were made to determine if any parameters in the software needed to be adjusted.

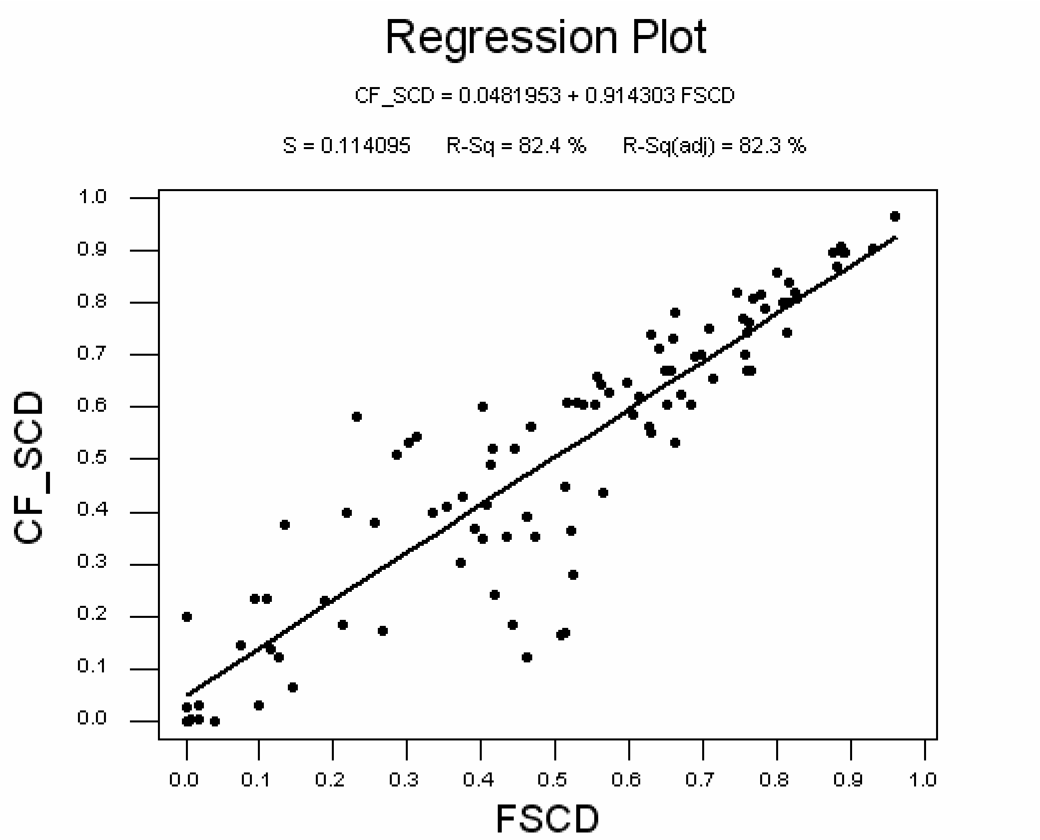


Fig. 1.5. Scatter plot of the fuzzy (FSCD) and crisp (CF_SCD) outputs for a developed stratigraphic carbonate play.

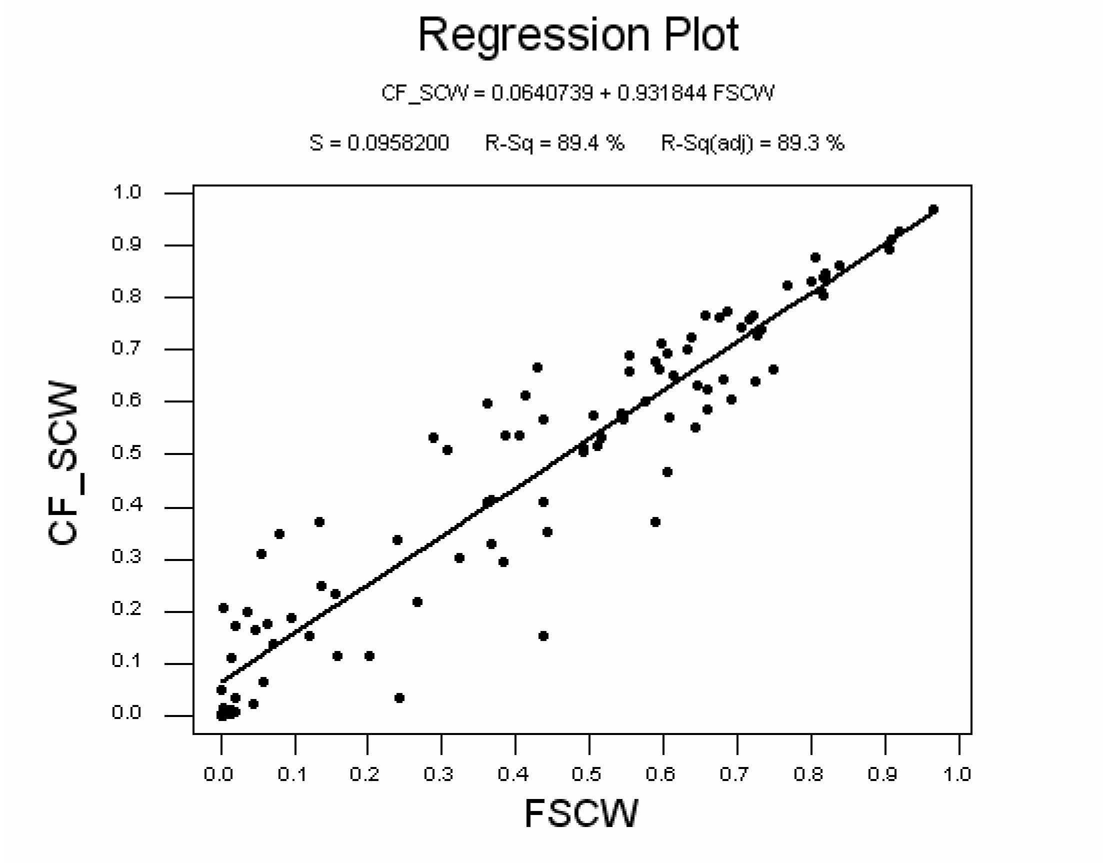


Fig. 1.6. Scatter plot of the fuzzy (FSCW) and crisp (CF_SCW) outputs for a wildcat stratigraphic carbonate play.

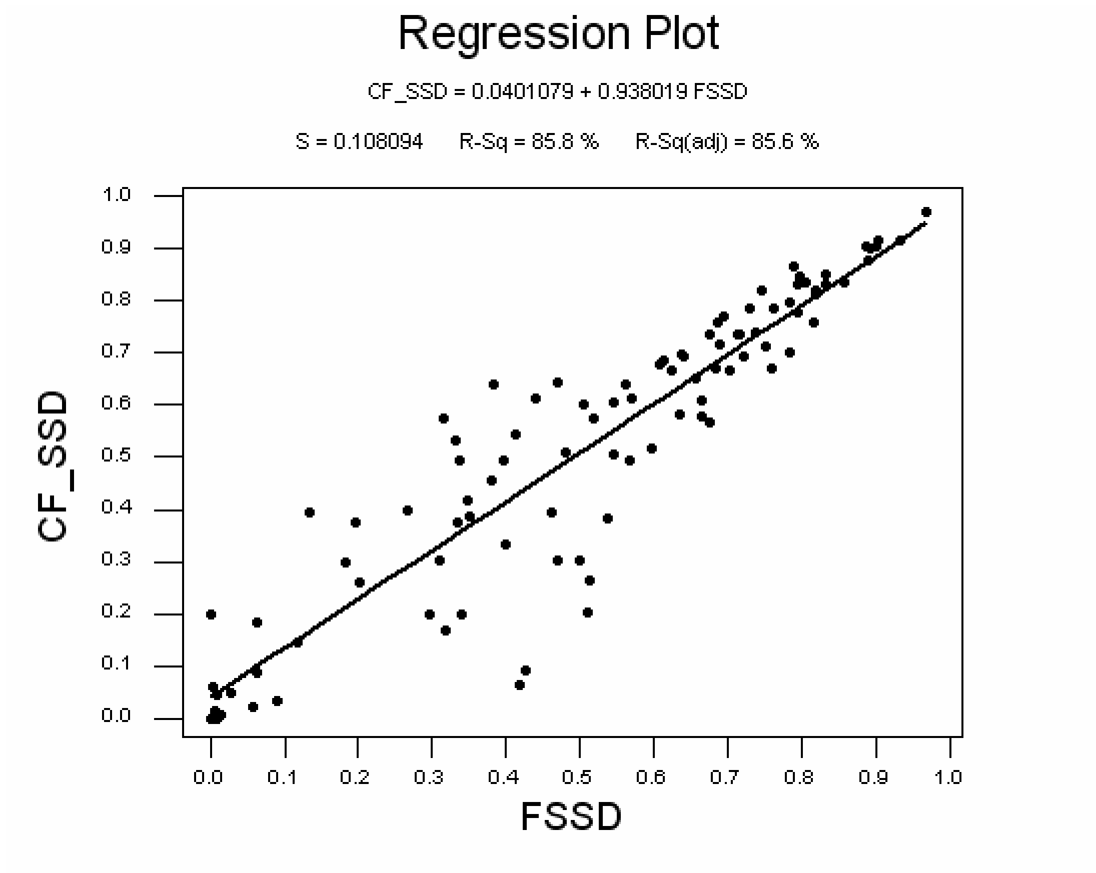


Fig. 1.7. Scatter plot of the fuzzy (FSSD) and crisp (CF_SSD) outputs for a developed stratigraphic sandstone play.

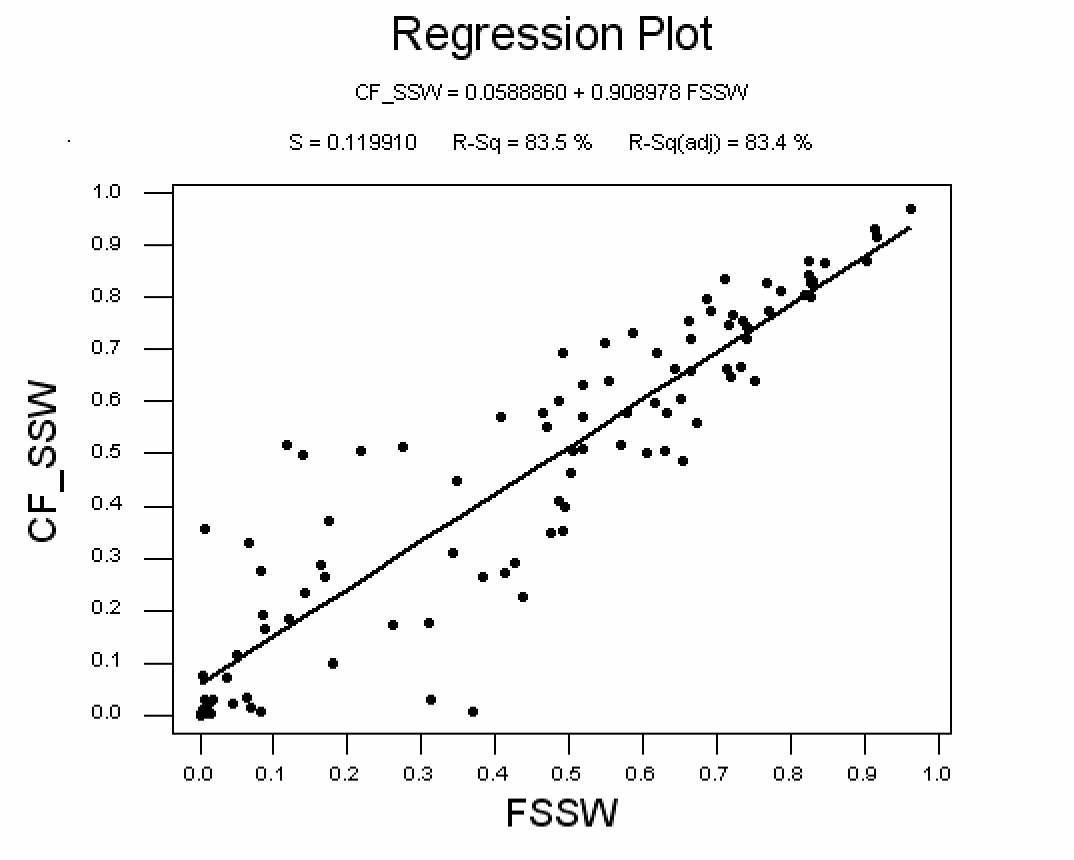


Fig. 1.8. Scatter plot of the fuzzy (FSSW) and crisp (CF_SSW) outputs for a wildcat stratigraphic sandstone play.

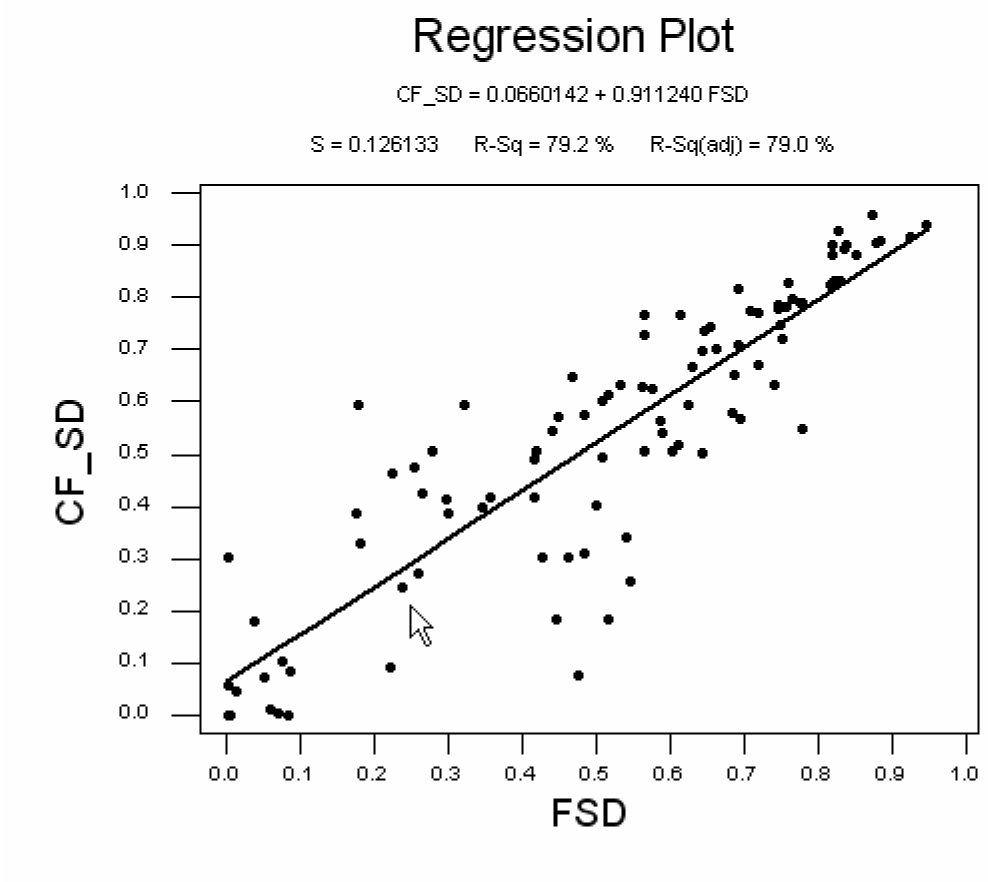


Fig. 1.9. Scatter plot of the fuzzy (FSD) and crisp (CF_SD) outputs for a developed structural play.

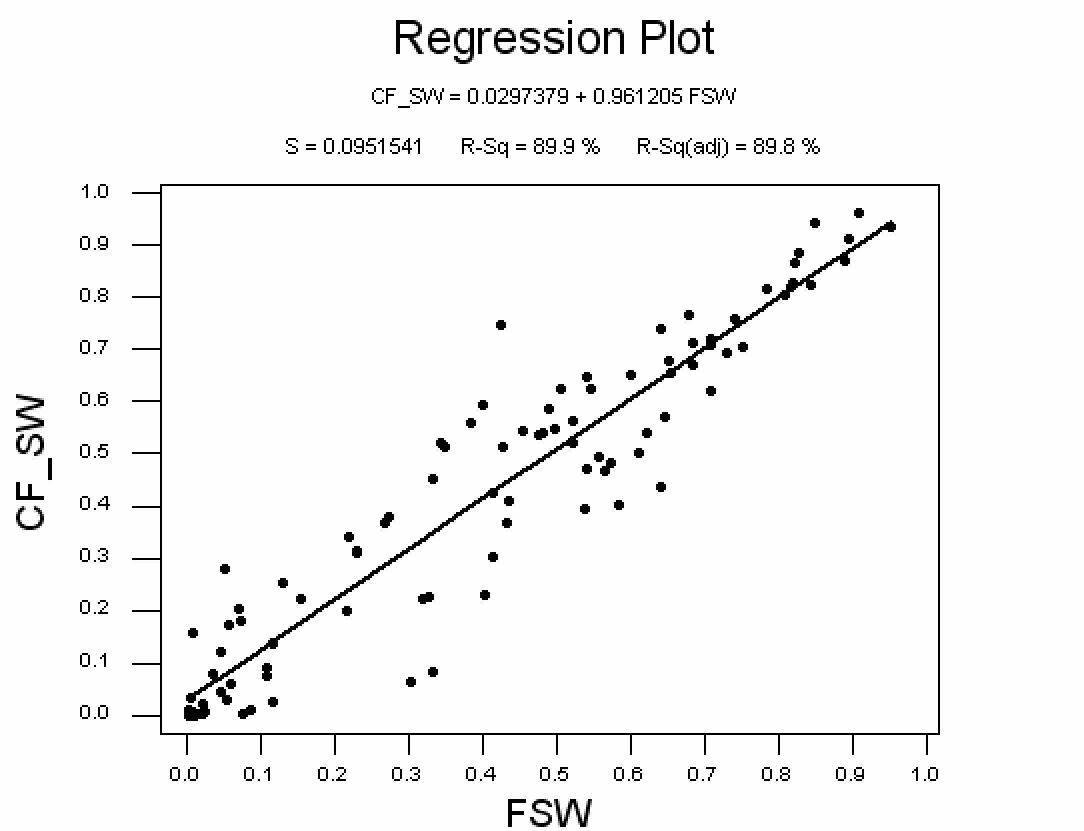


Fig. 1.10. Scatter plot of the fuzzy (FSW) and crisp (CF_SW) outputs for a wildcat structural play.

Statistical Analysis of User Data

Once work had significantly advanced on algorithm development, the assignment of fuzzy curves from a statistical analysis of raw user data was automated. Full pseudo-code was delivered to programmers and coding for the modular statistics tool begun. A summary of this process, which was ultimately set into a series of wizards, is as follows:

1) Read input data and store as $\{x_1 \ldots x_n\}$.

2) Sort the data in ascending order (re-number so that $x_i<x_j$ when $i<j$).

3) Compute the mean and the standard deviation.

4) Build a step cumulative distribution function for the data: $S_N(x)$. This function gives the fraction of the data points to the left of a given value of x. It is constant between consecutive values of x_i and jumps by 1/n at each x_i.

4) Computation of the Kolmogorov-Smirnov normality test comparing the step cumulative distribution function to the cumulative normal distribution function.

5) If the data is from a population that is normally distributed, fuzzy curves are drawn as follows:

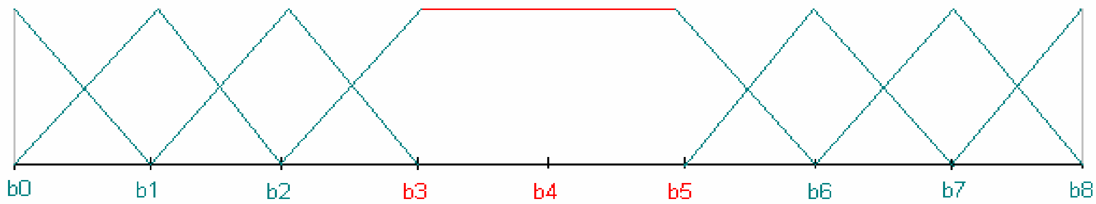


Fig. 1.11. Fuzzy curves for a normally distributed variable.

6) If the data set is not normal, a cumulative frequency distribution chart is developed. The computed frequencies help determine the shape of the distribution. Next, calculations are made to determine where the large frequencies are. Large frequencies are defined as being greater than the mean frequency + 1 standard deviation. The mean and standard deviation of the frequencies f_i} are then calculated. If $f_i \geq \bar{f} + s_f$, then the fuzzy curve is drawn as a trapezoid. In the cases where it is false, the fuzzy curve is drawn as a triangle.

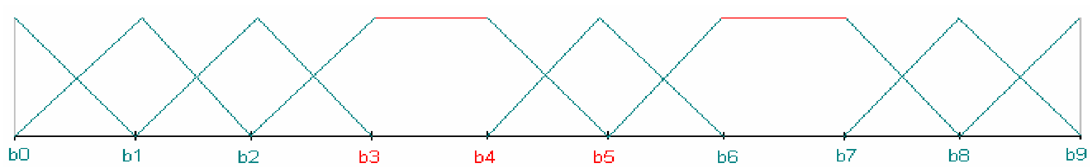


Fig. 1.12. Two non-adjacent bins where the frequency is "high."

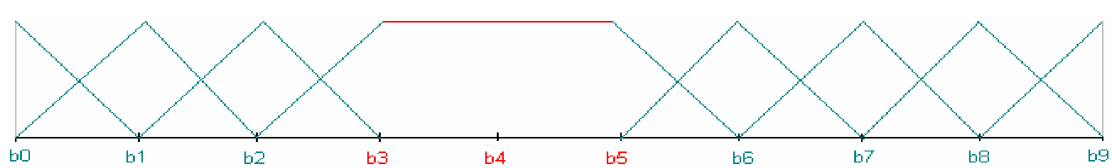


Fig. 1.13. Two adjacent bins where the frequency is "high."

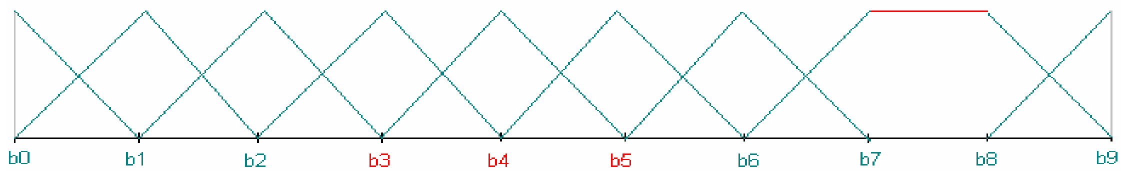


Fig. 1.14. One bin with high frequency (non-normal data).

The software outputs a recommended set of curves that is statistically valid for normal and non-normal data. These curves can be refined by the user, and the software will alert the user to significant anomalies.

2. Task 2: User Interfaces and Expert System Design Wizards

Interfaces to Populate and Manage Knowledgebase Information

A knowledgebase is defined as a "machine-readable resource for the dissemination of information, generally online or with the capacity to be put online," (May, 2001) and as "a collection of facts, relations, procedures etc., which constitute the knowledge about a particular domain." (Hart, 1986). The pre-set knowledge base of the CFS comprises expert knowledge from interviews, to which is added both user-defined and data-derived rules. The knowledgebase of an expert system consists of the rule sets whose input is numerical, or will be converted to a numerical format for computer analysis. This numerical data can also be used to generate fuzzy membership functions (or curves) that can be used by an inference engine to evaluate the rules using fuzzy logic rather than discrete or "crisp" inference techniques.

A key for successful implementation of the CFS is the ability to introduce and assimilate user data in a variety of formats and convert them for use by the inference engine. Therefore, a necessary component is user-friendly wizard-driven software that reviews the quantitative data provided by the user and develops fuzzy curves for that data and thus aids in development of data derived rules from the user provided raw data. Figure 2.1 shows a screen shot of the interface with all modules discussed later in this chapter.

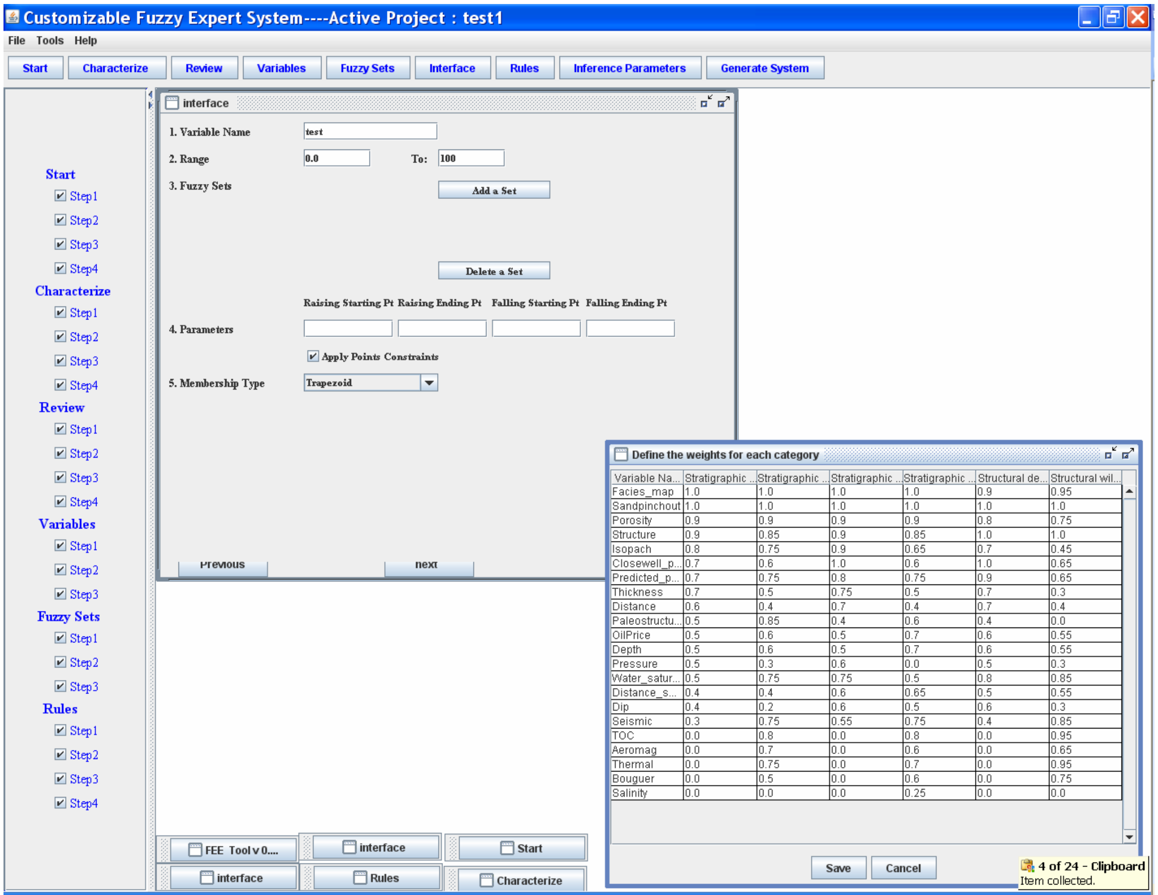


Fig. 2.1. CFS overall interface with all modules active.

Data-derived rules have to be developed when the user provides only the raw data as input. Therefore, a tool that reviews the quantitative data provided by the user and develops initial fuzzy curves for that data was designed. The architecture consists of three key modules – Data Cleaning, Normality Testing and Fuzzy Set Definitions. The fuzzy curves can be viewed using a separately developed module where they can be viewed and modified by the user before being used in their customized expert system. The architecture flowchart is shown in Fig. 2.2.

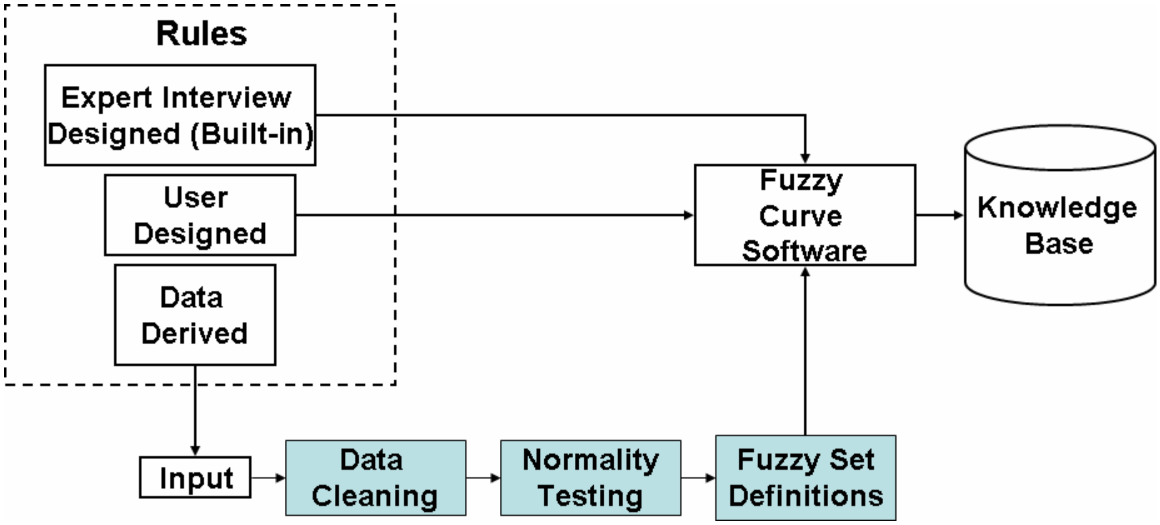


Fig. 2.2. Stages in the development of a CFS knowledgebase.

Data Cleaning Module

The user's data is first examined in the Data Cleaning module where the data is cleaned in two stages—Data Collection and Data Analysis (Xiong, 2006). In the data analysis stage, the data cleaning algorithms remove irrelevant or weakly irrelevant objects for the purpose of improving the results of data analysis. Detection and removal of errors is not the key focus in this stage of data cleaning. The data analysis can be done with different methods: distance-based, density-based and clustering-based. Xiong *et al.* (Xiong, 2006) described the data cleaning algorithms in the form of outlier detection algorithms. Distance-based algorithms identify the outliers based on the distance measure. Density-based algorithms identify the outliers in data sets with varying densities. Clustering-based algorithms identify the small clusters that are far away from other major clusters as sets of outliers. Using these definitions, the selected data-cleaning algorithm falls under the category of distance-based data cleaning algorithms. The cleaned data is then passed to the Normality Testing module to test the normality of the data.

Data Collection Stage: The data-cleaning algorithm takes user data and calculates two ranges, the error range and the warning range. A value outside the error range is typically a data entry error, and a value outside the warning range may be a possible data entry error or an outlier. In order to determine these ranges, the user defines a variable type. The types are proportional (decimal or %), nonnegative real, real, integer, whole, and natural.

The warning range is created by using distance-based outlier detection. The mean of the data ($\bar{x}$) and the standard deviation (s) are calculated. The interval $[\bar{x}-2s, \bar{x}+2s]$ is then computed, which implies that even if the data is not normally distributed, it will contain at least 75% of all values regardless of the distribution of the data set. The intersection of the interval above and the error range based on the variable type gives the warning range.

Example: Suppose the user wants to enter data for connate water saturation. The data is usually represented as a percentage, so the variable type selected is % proportion. The error range is thus [0,100].

To compute the warning range, suppose the mean of the user's data is 11% with a standard deviation of 6%. The interval built in the second step would be [11-2(6), 11+2(6)] or [-1, 23]. The intersection of the set [-1, 23] and [0,100] is [0, 23], so this is the warning range.

A data value of -2% or 105% would fall outside the error range; a pop-up tells the user that the value is outside the domain of the data. A data value of 50% would fall outside the warning range, so a pop-up will recommend that the user verify the value. A data value of 16% would be inside both ranges, and would not raise any flags.

Data Analysis Stage: The selected algorithm uses a distance-based outlier detection algorithm based on Xiong *et al.* (Xiong, 2006). They define a distance-based method as follows:

"An object in a data set D is a distance-based outlier if at least a fraction α of the objects in D are at a distance greater than r."

Figure 2.3 describes the pseudocode of the proposed distance-based data cleaning algorithm. r and α are accepted from the user as input. N is the total number of data points. x is an one-dimensional array that contains all the N data points. N_r is the number of data points that lie within a distance r from the mean. N_α is the number of data points that represent a fraction α of the N. The **For** loop traverses the whole array and determines the number of data points that lie within a distance r from its mean. The data points are sorted with respect to the distance from the mean. The points that are farthest away from the mean are considered as noise and hence removed. To do this, the algorithm considers the greater of the two, N_r or N_α. The first N_r or N_α (whichever is greater) data items are considered as clean and the rest are considered as noise.

```
Nr := 0;
For i:= 1 to N do
  Distance[i] :=Mod(x[i] - mean)/sd;
  If (Distance[i]< r) then
     Nr := Nr + 1;
  End If
End For
Sort (X,ascending,distance from mean);
Nα := N * α;
If (Nr < Nα)then
  Clean Data Set := X[1.. Nα];
Else
  Clean Data Set := X[1..Nr];
End If
```

Fig. 2.3: Algorithm pseudocode: distance-based data cleaning.

Summary and Justification: The selected algorithm has a complexity of O(n) while the algorithm proposed by Xiong *et al.* has a complexity of $O(n^2)$. This is because the algorithm by Xiong *et al.* calculates data items with the least number of neighbors within a specified radius and requires two **For** loops to achieve the same. The selected algorithm in this research is faster than the algorithm by Xiong *et al*. The drawback of the proposed algorithm is that it does not clean data efficiently when the data set is irregular or skewed.

Table 2.1 illustrates the selected algorithm with an example consisting of 20 data items. The first column represents the index of the array x. The second column represents all the unsorted data elements and their corresponding distance from the mean. The third column represents the data elements that are sorted in ascending order of distance from the mean. Let the values of the global parameters be as follows: r = 2, α = 0.95. After executing the algorithm, it was found that $N_r = 18$, and $N_\alpha = 19$. Since $N_\alpha > N_r$, a clean set consists of 19 items from the sorted data set.

Table 2.1. Results of Distance-Based Outlier Algorithm

	Unsorted		Sorted according to distance	
Index (i)	X[i]	Distance from mean	X[i]	Distance from mean
1	15.75	0.26	15.36	0.03
2	16.16	0.50	15.26	0.03
3	14.97	0.21	15.15	0.10
4	19.25	2.34	15.51	0.12
5	13.35	1.17	15.58	0.16
6	15.51	0.12	15.61	0.18
7	14.15	0.70	14.97	0.21
8	15.26	0.03	15.75	0.26
9	15.36	0.03	16.15	0.49
10	13.41	1.13	16.16	0.50
11	15.15	0.10	16.45	0.68
12	14.12	0.71	14.15	0.70
13	16.63	0.78	14.12	0.71
14	19.47	2.47	16.63	0.78
15	15.58	0.16	13.86	0.87
16	16.15	0.49	13.41	1.13
17	12.66	1.58	13.35	1.17
18	13.86	0.87	12.66	1.58
19	15.61	0.18	19.25	2.34
20	16.45	0.68	19.47	2.47

Nr Nalpha

Mean=15.32, SD=1.68, r=2, N_r=18, α =0.95, N_α =19

The drawback of distance-based algorithms is that they cannot consider points in different densities.

The experiments are performed using two data sets for *normal* and *not normal* data with the parameters of r and α changed arbitrarily. The data sets are generated using excel having 100 entries. The *normal* data set has a mean of 4.9 and standard deviation of 0.99.

Table 2.2 shows the percentage of data used for normality testing for *normal* and *not-normal* distributions after filtering the data based on changing the values of r and α. For *normal* data, 68% of the data falls between $\bar{x} - s$ and $\bar{x} + s$ and 96% of the data falls between $\bar{x} - 2s$ and $\bar{x} + 2s$.

The *normal* data with r = 1.00 and α = 0.50 filters 32% of the data which makes the distribution of the data as *not-normal*. Thus, parameter selection plays a significant role in determining the output of the program.

Table 2.2. Experimental Results for the Proposed Data-Cleaning Algorithm

r	α	Normal Data	Not Normal Data
1.00	0.50	0.68	0.64
1.50	0.50	0.85	0.89
2.00	0.50	0.96	0.99
1.00	0.75	0.75	0.75
1.50	0.75	0.85	0.89
2.00	0.75	0.96	0.99
1.00	0.90	0.90	0.90
1.50	0.90	0.90	0.90
2.00	0.90	0.96	0.99

Normality Testing Module

Kolmogorov-Smirnov (K-S), Lilliefors, and Shapiro-Wilks are commonly described normality tests available in the literature. Kolmogorov-Smirnov is based on maximum difference between the sample cumulative distribution and the hypothesized cumulative distribution. Lilliefors is an extension of K-S but the mean and SD of the hypothesized distribution are estimated from sample data. Shapiro-Wilks has good power properties but is difficult to implement. One of the most common used goodness-of-fit tests is the chi-square test. The advantage of this test is that it can be used with any type of input data (sample, density or cumulative) and any type of distribution function (discrete or continuous). A weakness of the chi-square test is that there are no clear guidelines for selecting intervals, which increases difficulty of implementation for lay users. The test is considered subjective because it depends on the user-supplied intervals specifications (Jankauskas, 1995). The K-S test does not depend on the number of intervals, which makes it more powerful than the chi-square test, though it has weaknesses in detecting tail discrepancies.

The Normality Test module uses the K-S algorithm to test the normality of the data. It is based on the maximum difference between sample cumulative distribution and the hypothesized distribution. The fuzzy set definitions are then derived based on the fuzzy set definition algorithms for both normal and not-normal data. The Fuzzy Set Definitions module provides the starting point with a number of basic rule sets that apply to a variety of formation types. Users can then add to, delete or modify these rule sets. The fuzzy curve software allows users to view and modify the fuzzy curves before being used by their customized expert system.

Normality Testing: The cleaned data that resulted from the Data Cleaning module is given to the Normality Testing module. This is used to test if the data provided by the user is normally distributed or not. This section explains the K-S algorithm which is used for normality testing and the illustrations and histograms for the *normal* and *not normal* data.

Statistical Algorithm—Normal and Not-Normal Data: Figure 2.4 illustrates the Statistics module used in this project. There are different subtasks in the statistics module. The user data is read and then analyzed for errors. Then, the data is passed on to the Normality Test module. Here, the data is tested for normality. After this test, the data is labeled either as *normal* or *not-normal*. The histograms/box plots are drawn as graphical output. The labeled data is then passed on to the Fuzzy Set Definition module, which generates the definitions for the fuzzy sets. The definitions can be viewed using fuzzy curve software.

The Normality Test module uses the K-S algorithm to test the normality of the data. It is based on the maximum difference between the sample cumulative distribution and the hypothesized cumulative distribution. The algorithm is listed below:

1. The step cumulative distribution function for the data: $S_N(x)$ gives the fraction of the data points to the left of a given value of x. It is constant between consecutive values of x_i and jumps by 1/n at each x_i.

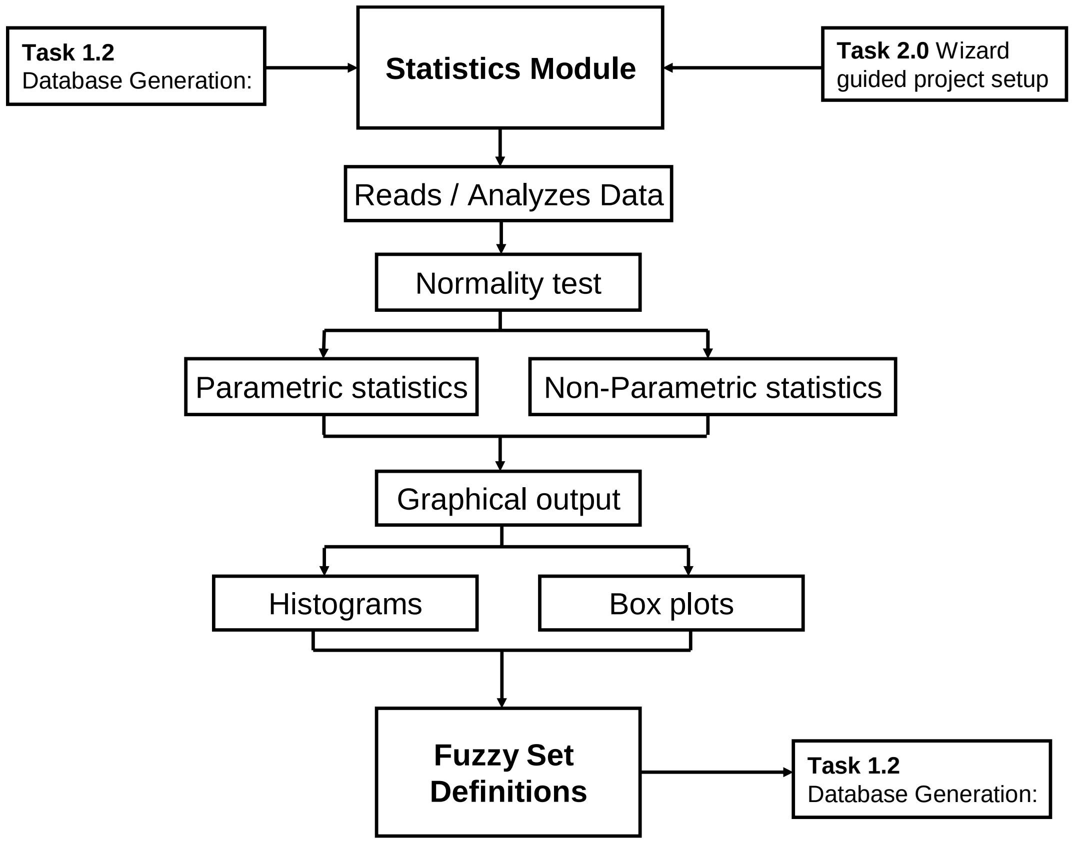


Fig. 2.4. Overview of the Statistics Module.

2. Cumulative normal distribution function is calculated using the following equation:

$$P(x) = \frac{1}{2}\left(1 + erf\left(\frac{x - \bar{x}}{s\sqrt{2}}\right)\right)$$

3. With the function P(x) and $S_N(x)$, K-S statistic, D is computed as below:

$$D = \max_{-\infty < x < \infty} \left| S_N(x) - P(x) \right|$$

4. Then the significance of D is calculated by computing Q_{KS}:

$$Q_{KS}(\sqrt{n}D) = 2\sum_{j=1}^{\infty} \left(-1\right)^{j-1} e^{-2j^2(\sqrt{n}D)^2}$$

This is an infinite series that should converge to a value between 0 and 1. If this value of Q is small, the data is not normally distributed (Q < 0.10) is good for these purposes.

In step 2 of the algorithm, the formula given does not contain an explicit closed-form solution for calculation of the integral. Abramowiz and Stegun (Abramowicz, 1964) contains an approximation of P(x). Figure 2.5 lists that part of the java code below from 'NormalityTest.java':

```
public double CNDF(double z)
{
          if (z> 6.0) return 1.0;
          if (z<-6.0) return 0;
          double b1 = 0.31938153;
          double b2 = -0.356563782;
          double b3 = 1.781477937;
          double b4 = -1.821255978;
          double b5 = 1.330274429;
          double p = 0.2316419;
          double c2 = 0.3989423;
          double a = Math.abs(z);
          double t = 1.0/(1.0 + a*p);
          double b = c2 * Math.exp((-z)*(z/2.0));
          double n = ((((b5 * t + b4)*t+b3)*t+b2)*t+b1)*t;
          n = 1.0 - b*n;
          if (z<0.0) n = 1.0 - n;
          return n;
}
```

Fig. 2.5. Calculation of P(x).

Implementation of the code for normality testing requires validation. Four datasets (two *normal* distributions and two *not-normal* distributions) were used for the validation process. Tables 2.3 and 2.4 show the results of applying K-S test to *normal* data and *not-normal* data, respectively.

Table 2.3. Normal Data

S(x)	P(x)
0.05	0.012890285
0.10	0.051603599
0.15	0.083870383
0.20	0.173737036
0.25	0.239007063
0.30	0.281125892
0.35	0.322937607
0.40	0.367116629
0.45	0.440579556
0.50	0.496210107
0.55	0.528102197
0.60	0.621909537
0.65	0.637018176
0.70	0.648212782
0.75	0.677421284
0.80	0.702117353
0.85	0.705573883
0.90	0.925136958
0.95	0.969980081
1.00	9.93E-01

Table 2.4. Not-Normal Data

S(x)	P(x)
0.05	0.063380528
0.10	0.065905357
0.15	0.072558233
0.20	0.075359044
0.25	0.085812715
0.30	0.102577716
0.35	0.109911365
0.40	0.117613876
0.45	0.131997214
0.50	0.134147013
0.55	0.182203376
0.60	0.252386009
0.65	0.255590402
0.70	0.364295739
0.75	0.40632846
0.80	0.477272551
0.85	0.556854913
0.90	0.944419902
0.95	0.999999961
1.00	1

Figures 2.6 and 2.7 show the K-S statistic for the *normal* and *not-normal* data, respectively. The y-axis in these graphs follows a log-normal scale. In the case of the *normal* data (Fig. 2.6), the maximum distance between P(x) and S(x) is very less. In the case of the *not-normal* data (Fig. 2.7), there is significant difference between the cumulative distributions.

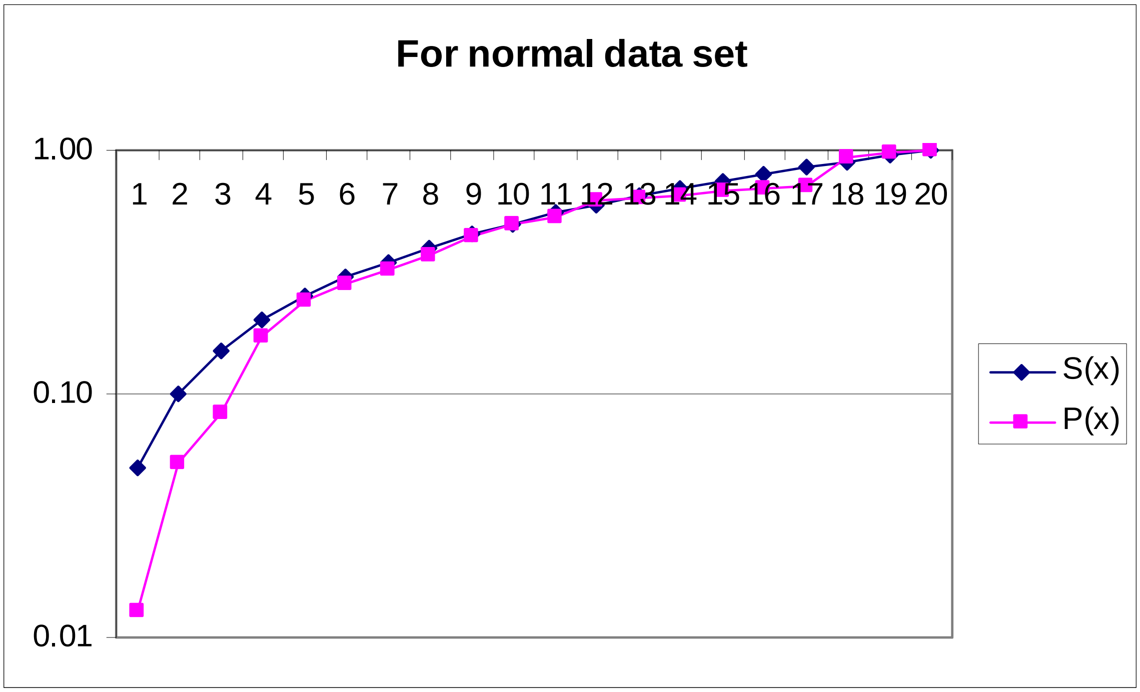


Fig. 2.6. K-S statistic for *normal* data.

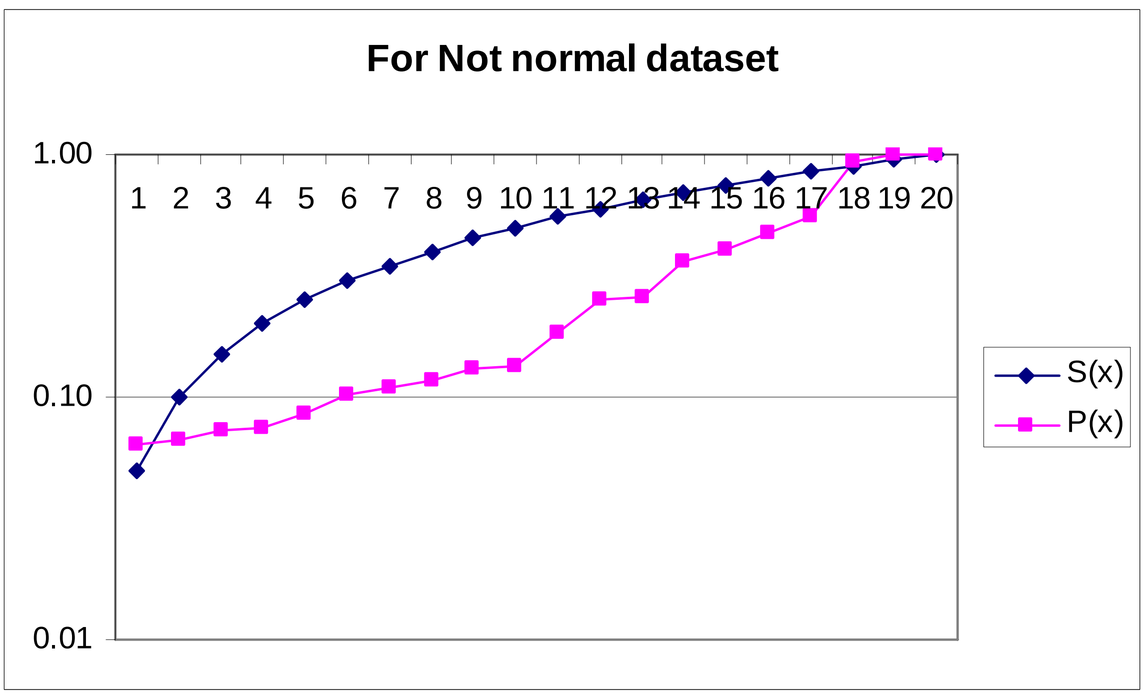


Fig. 2.7. K-S statistic for *not-normal* data.

Figure 2.8 shows the histogram for a larger test set of *normal* data having mean 4.9 and standard deviation of 0.99. It has the shape of a bell curve.

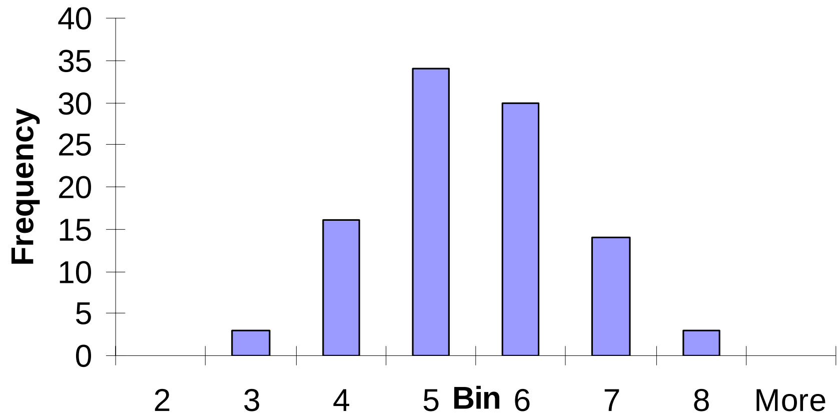


Fig. 2.8. Histogram for *normal* data.

Figure 2.9 shows the k-s statistic for *normal* data. It is a lognormal scale graph having the values of S(x) and P(x). The x-axis has the number of data points, which is 100. It is observed that the difference between S(x) and P(x) is the minimum for the *normal* data.

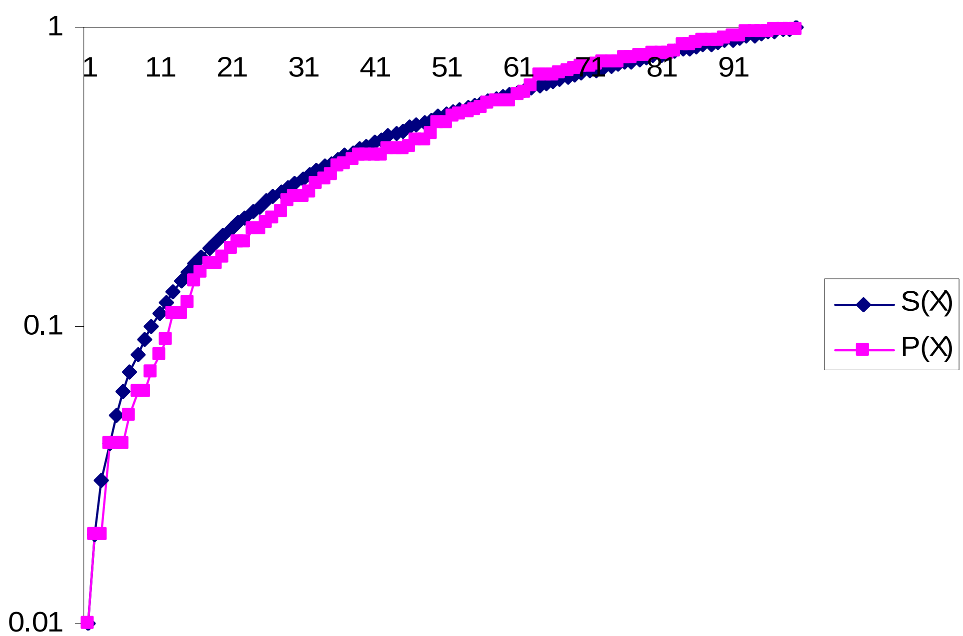


Fig. 2.9. Illustration of k-s statistic for *normal* data.

Figure 2.10 shows the histogram for the *not- normal* data having mean 36.46 and standard deviation of 30.65. Figure 2.11 shows the k-s statistic for *not-normal* data. It is a lognormal scale graph having the values of S(x) and P(x). The maximum difference between P(x) and S(x) is large in case of *not-normal* data.

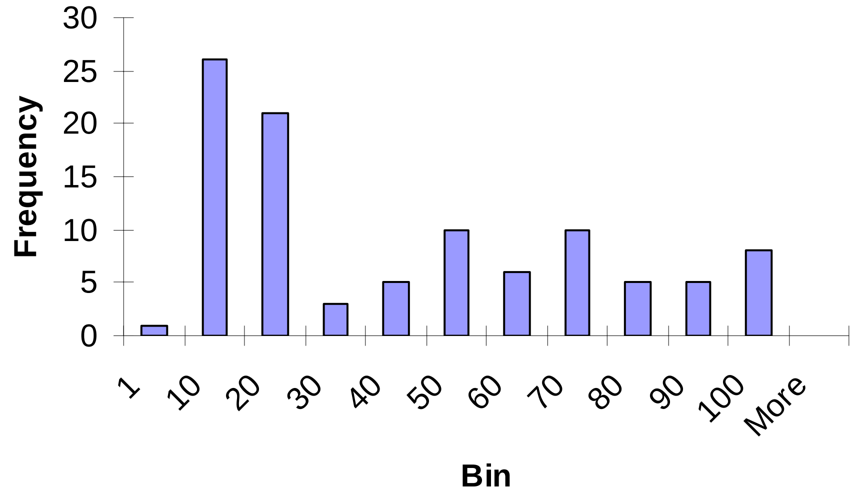


Fig. 2.10. Histogram for *not-normal* data.

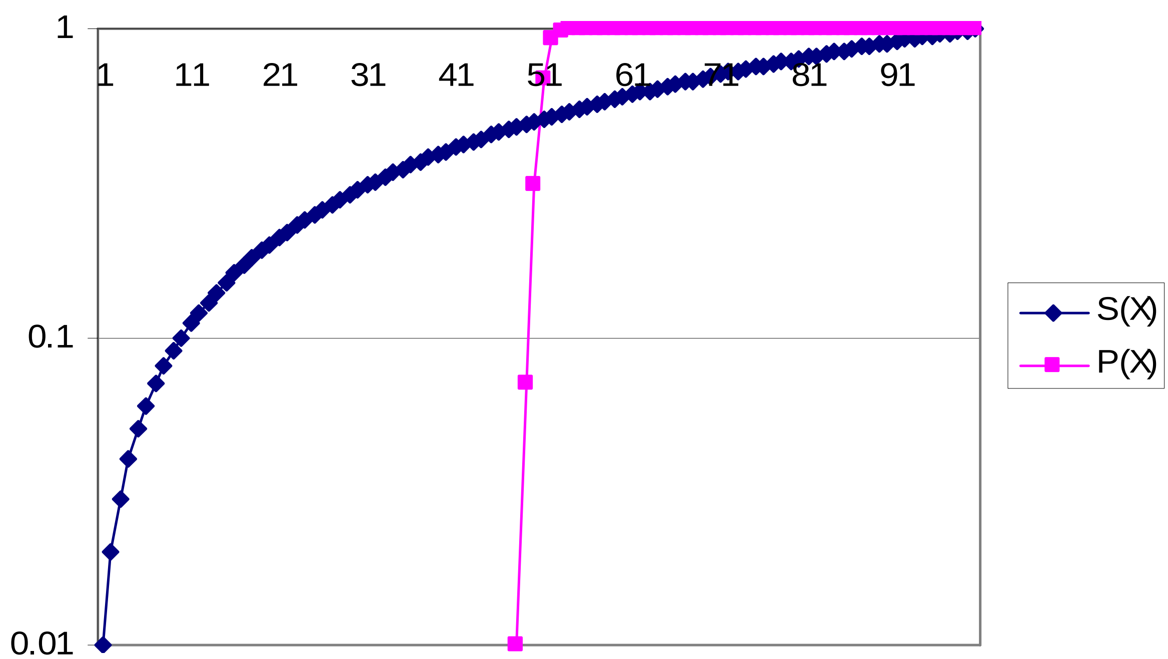


Fig. 2.11. Illustration of k-s statistic for *not-normal* data.

These examples illustrate the need for the fuzzy curve generation software to understand the data distributions, and then address *normal* and *not- normal* data in the curve selection process. Values of the K-S statistic provide a ready measurement of which approach to take when generating fuzzy sets for user-provided data streams

Fuzzy Curve Generation Module

Fuzzy Set Definition Algorithm—*Normal* Data: The empirical rule states that normally distributed data has 68% of its data points between $\bar{x} \pm s$, 95 % between $\bar{x} \pm 2s$ and 99% of the data between $\bar{x} \pm 3s$. If data is from a population that is normally distributed, fuzzy curves are drawn as in Fig. 2.12 with end point values from b0 to b9.

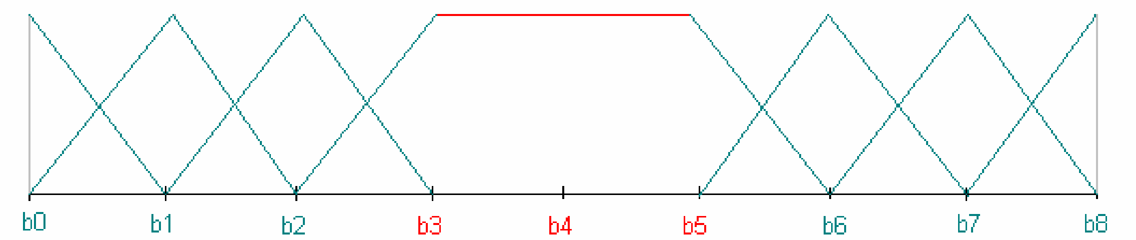


Fig. 2.12. Fuzzy curves for normal data.

Note:

$b0 = \bar{x} - 3s, b1 = \bar{x} - 2s, b2 = \bar{x} - s, b3 = \bar{x} - s/2, b4 = \bar{x}, b5 = \bar{x} + s/2, b6 = \bar{x} + s, b7 = \bar{x} + 2s, b8 = \bar{x} + 3s$

It is observed that 68% of all data points will fall between b2 and b6, 95% of all data points will fall between b1 and b7 and 99% of all data points will fall between b0 and b8.

Fuzzy Set Definition Algorithm—*Not-Normal* Data: In this case, a cumulative frequency distribution chart is developed and the frequencies determine the shape of the distribution. The variable n is the sample size, m is the number of bins or classes, b_j is the boundary of the bin, f_j is the frequency for each bin, and r is the range x_n- x_1. The following steps illustrate the algorithm:

1. First the boundaries of the bins $\{b_j\}$ are calculated as follows:

$$
\begin{aligned}
& m = 9 \\
& b_0 = x_1 \\
& r = x_n - x_1 \\
& w = r / m \\
& for\ \ j = 1\ to\ m \\
& \quad b_j = b_{j-1} + w \\
& next
\end{aligned}
$$

2. All the frequencies are initialized to 0 before calculating the frequency for each bin:

$$
\begin{aligned}
& For\ i = 1\ to\ n \\
& \quad For\ j = 1\ to\ m \\
& \qquad if\ \ b_{j-1} \le x_i < b_j \\
& \qquad then\ \ f_j = f_j + 1 \\
& \quad next
\end{aligned}
$$

3. Large frequencies are determined by comparing the frequency at each bin with the sum of mean frequency and standard deviation. The mean and standard deviation of the $\{f_i\}$ are calculated using the equation

$$
\bar{f} = \sum_{i=1}^{m} f_i / m \qquad s_f = \sqrt{\frac{1}{m}\sum_{i=1}^{m}\left(f_i - \bar{f}\right)^2}
$$

4. The large frequencies obtained from the inequality $f_i \ge \bar{f} + s_f$ determine the shape of the fuzzy curve. In the cases where the above inequality is true, the fuzzy curve is drawn with a trapezoid. In the cases where it is false, the fuzzy curve is drawn as a triangle.

The different cases of n*ot- normal* data based on the high frequency bin are explained with the help of an example. The highlighted frequencies are above the sum of the mean and the standard deviation.

Case 1: The data has two non-adjacent bins where the frequency is "high." Table 2.5 shows the frequency at each bin having lower and upper bound. There are two high frequency bins, 21 and 17, which are not adjacent.

Table 2.5. Frequency at Each Bin Having Two Non-Adjacent High Frequency Bins

lower	upper	f		
b0	b1	4	9.3	mean $\bar{f}$
b1	b2	3	6.1	standard dev. s_f
b2	b3	7	15.4	mean + s.d.
b3	b4	21		
b4	b5	9		
b5	b6	7		
b6	b7	17		
b7	b8	11		
b8	b9	5		

Figure 2.13 shows the fuzzy curves for the *not-normal* data where there are two high frequency bins that are not adjacent.

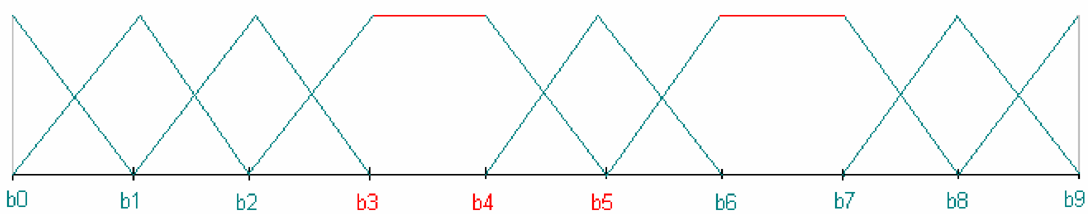


Fig. 2.13. Fuzzy curves for *not-normal* data having two non-adjacent high frequency bins.

Case 2: The data has two adjacent bins where the frequency is "high." Table 2.6 shows the frequency at each bin with its lower bound and upper bound. There are two high frequency bins, 21 and 19, which are adjacent to each other.

Table 2.6. Frequency at Each Bin Having Two Adjacent High Frequency Bins

lower	upper	f		
b0	b1	4	9	mean $\bar{f}$
b1	b2	3	6.5	standard dev. s_f
b2	b3	7	15.5	mean + s.d.
b3	b4	21		
b4	b5	19		
b5	b6	7		
b6	b7	9		
b7	b8	6		
b8	b9	5		

Figure 2.14 shows the fuzzy curves for the *not-normal* data having two adjacent high frequency bins. The adjacent high frequency bins merge into a single curve.

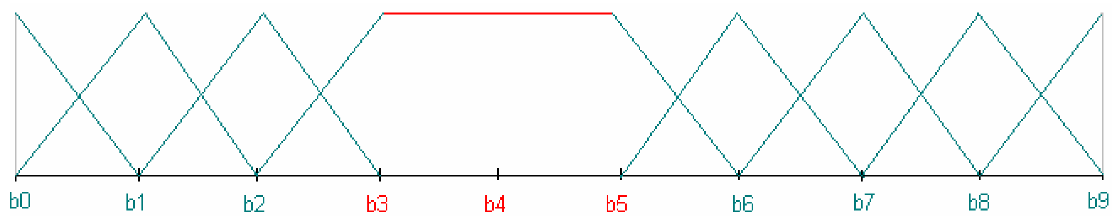


Fig. 2.14. Fuzzy curves for *not-normal* data having two adjacent high frequency bins.

Case 3: The data has one high frequency bin. Table 2.7 shows the lower bound, upper bound and frequency at each bin. There is one high frequency bin (Jankauskas, 1995). Figure 2.15 shows the fuzzy curves for the *not-normal* data having one high frequency bin.

Table 2.7. Frequency at Each Bin Having One High Frequency Bin

lower	upper	f		
b0	b1	4	5.7	mean $\bar{f}$
b1	b2	3	1.8	standard dev. s_f
b2	b3	7	7.5	mean + s.d.
b3	b4	6		
b4	b5	5		
b5	b6	7		
b6	b7	5		
b7	b8	9		
b8	b9	5		

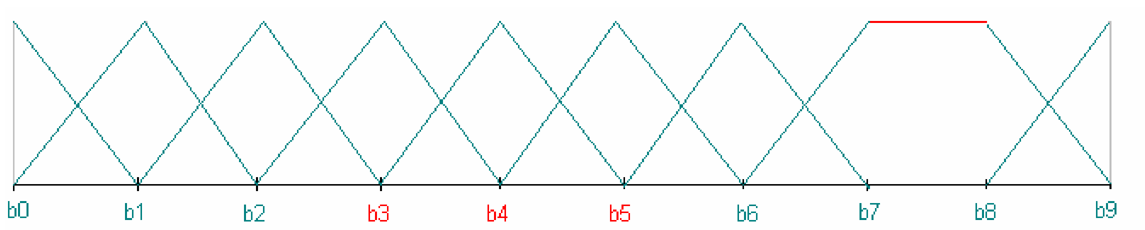


Fig. 2.15 Fuzzy curves for *not-normal* data having one high frequency bin.

Case 4: The data has no high frequency bins and data is uniformly distributed. Table 2.8 shows the frequency at each bin with its lower and upper bound. There are no high frequency bins. Figure 2.16 shows the fuzzy curves of the *not-normal* data having no high frequency bins.

Table 2.8. Frequency at Each Bin Having No High Frequency Bins

lower	upper	f		
b0	b1	5	4.7	mean $\bar{f}$
b1	b2	4	0.5	standard dev. s_f
b2	b3	5	5.2	mean + s.d.
b3	b4	5		
b4	b5	4		
b5	b6	5		
b6	b7	5		
b7	b8	5		
b8	b9	4		

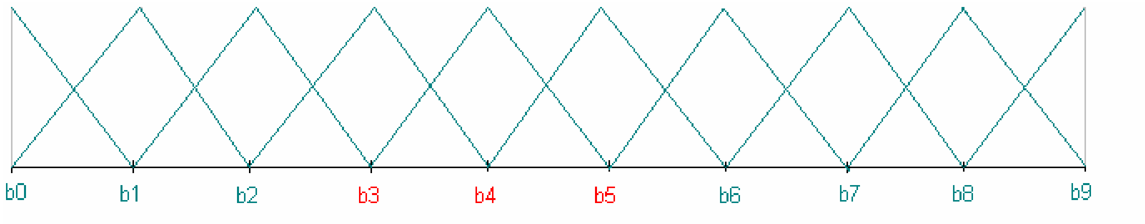


Fig. 2.16. Fuzzy curves for *not-normal* data with no high frequency bin.

It is observed that when the bins have high frequency, the curves are trapezoidal, with a horizontal top line connecting the lower and upper boundaries of the bins. If the bins do not have a high frequency, the curves are triangular, with an apex at each bin endpoint. When there are two or more high frequency bins that are adjacent, the curves merge into one curve.

Fuzzy Curve Generation Software: Implementations of the fuzzy curve generation have been completed. The Fuzzy Curve Generation module generates fuzzy curves for *normal* data and *not-normal* data with minimal or intensive user interaction. Figure 2.17 shows a screen capture of software generated fuzzy curves for a *normal* data set.

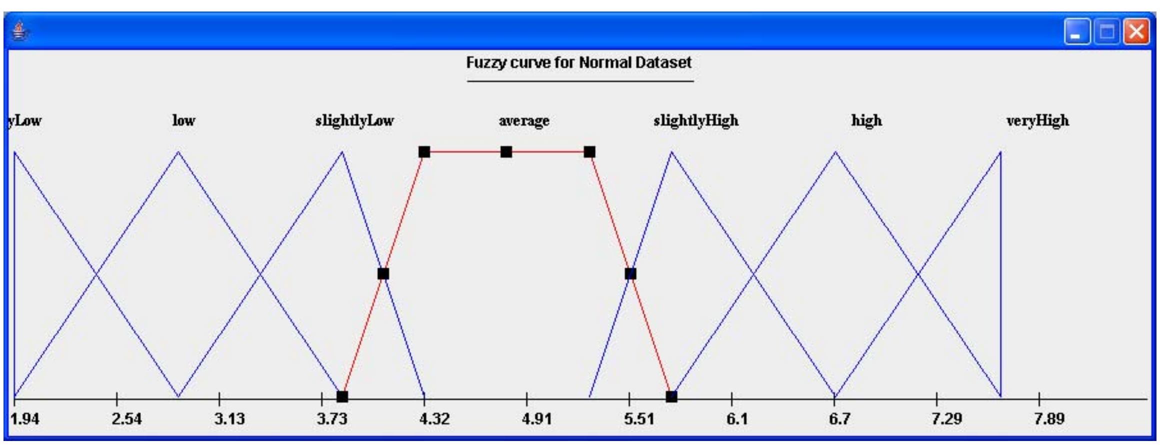


Fig. 2.17. Fuzzy curves for the *normal* data.

The *not-normal* data set has different cases based on the high frequency which are obtained after the filtering of data using data cleaning algorithm. Again, several cases or types of curve distributions are presented for the purpose of illustrating the concepts.

Case I: The size of the *not-normal* data after data analysis is 64, the sum of mean and standard deviation is 12.48. Table 2.9 has the lower bound and upper bound for each bin and its frequency. There are two high frequency bins whose value is greater than the sum of mean and standard deviation. In this case, two adjacent high frequency bins results in a single large curve covering the range of data for the two high frequency bins. Figure 2.18 shows the result of merging the two adjacent high frequency bins.

Table 2.9. Frequency of Each Bin When Size Is 64

Lower Bound	Upper Bound	Frequency
6.00	12.78	19
12.78	19.56	14
19.56	26.33	2
26.33	33.11	4
33.11	39.89	6
39.89	46.67	2
46.67	53.44	7
53.44	60.22	3
60.22	67.00	6

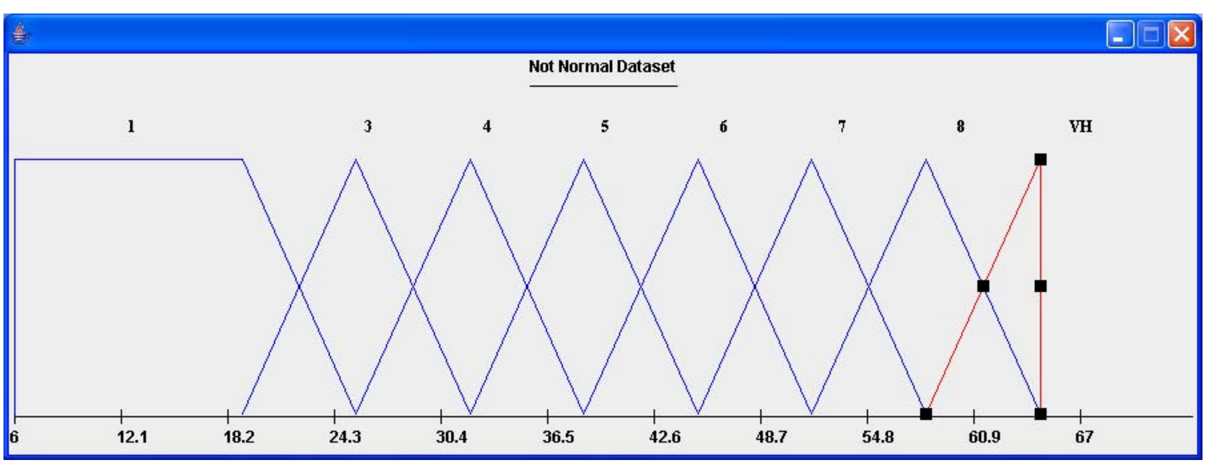


Fig. 2.18. Fuzzy curves for the *not-normal* data having adjacent high frequency bins.

Case II: Size of the *not-normal* data after data analysis is 75; the sum of the mean and standard deviation is 8.64. Table 2.10 has the lower bound and upper bound for each bin and its frequency. There are two nonadjacent high frequency bins whose value is greater than the sum of mean and standard deviation. Figure 2.19 shows these two high frequency bins that are not adjacent. Again, a bin without high frequency has curves which are triangular, with an apex at each bin endpoint.

Table 2.10. Frequency of Each Bin When Size Is 75 (Case II)

Lower Bound	Upper Bound	Frequency
13.00	21.22	9
21.22	29.44	8
29.44	37.67	8
37.67	45.89	8
45.89	54.11	9
54.11	62.33	8
62.33	70.56	8
70.56	78.78	8
78.78	87.00	8

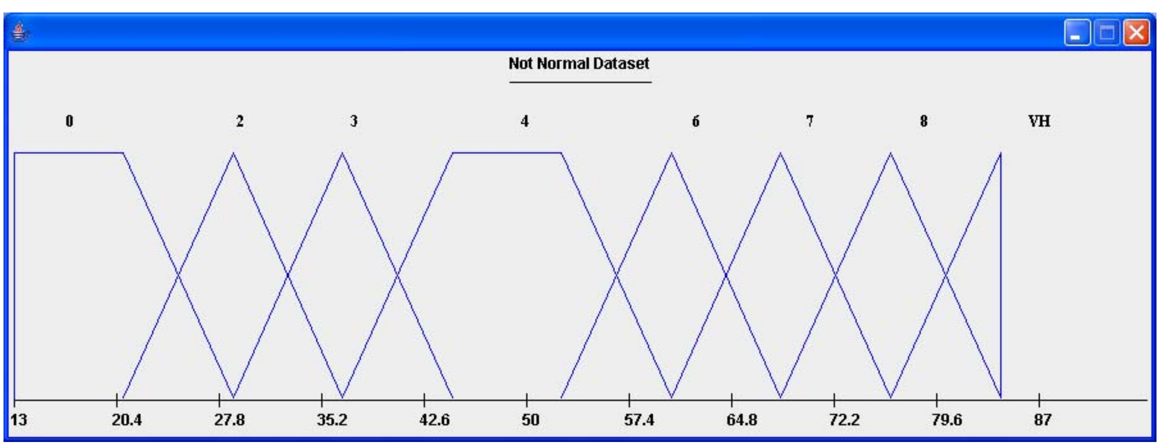


Fig. 2-19. Fuzzy curves for *not-normal* data having two nonadjacent high frequency bins.

Case III: The size of the *not-normal* data after data analysis is 100; the sum of the mean and standard deviation is 11. Table 2.11 has the lower bound and upper bound for each bin and its frequency. The frequency at each bin is equal to the sum of mean and standard deviation. Figure 2.20 shows the fuzzy curves for the *not-normal* data where there is a single frequency bin. It is observed that when there are two or more high frequency bins that are adjacent, the curves merge into one curve. Note this is a very unlikely scenario.

Table 2.11. Frequency of Each Bin When Size Is 75 (Case III)

Lower Bound	Upper Bound	Frequency
1.00	12.00	11
12.00	23.00	11
23.00	34.00	11
34.00	45.00	11
45.00	56.00	11
56.00	67.00	11
67.00	78.00	11
78.00	89.00	11
89.00	100.00	11

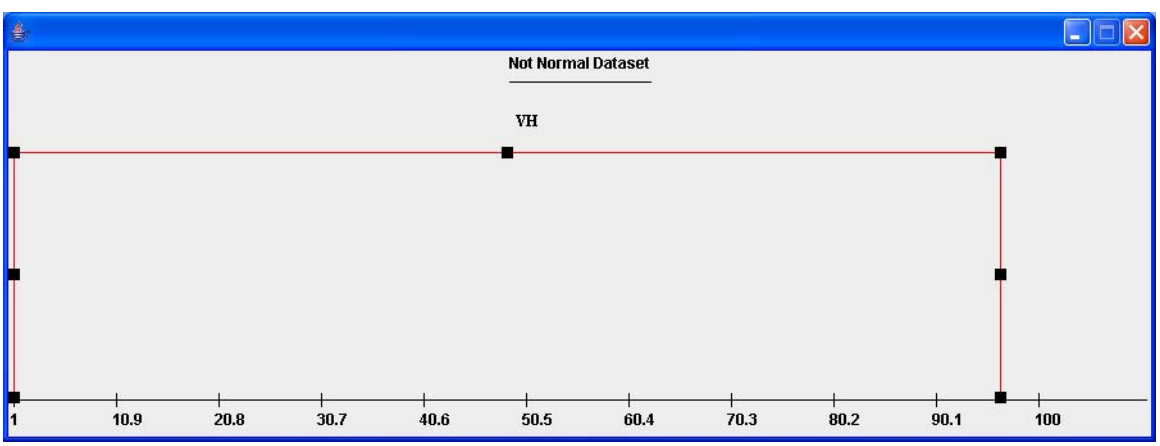


Fig. 2.20. Fuzzy curves for the *not-normal* data having one high frequency bin.

User Interface for Fuzzy Curve Software

The sequential flow of the Fuzzy Set Panel has four panels attached to it which allow the user to view curves and modify, add or delete fuzzy sets. The Fuzzy Set Panel is the main panel developed to allow the user to navigate between each of the panels. Figure 2.21 shows the *Variable Select Panel,* which allows the user to select a fuzzy variable to work with. The fuzzy curves can be viewed or modified using the panel.

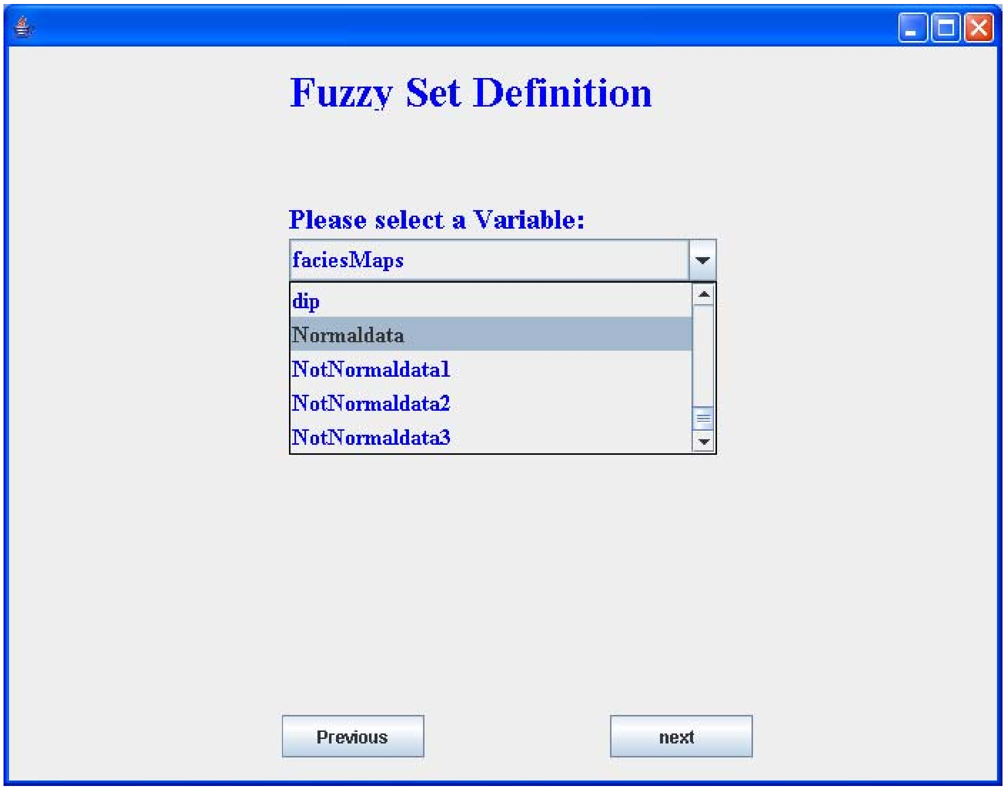


Fig. 2.21. Screenshot of the variable select panel.

Each step in the Fuzzy Set module was implemented as a sequential flow, which allows the user to select the options in the Fuzzy Set Operations Select Panel (Operations Panel). Figure 2.22 shows the operations panel in which the following actions take place when the "next" button is clicked:

a. When the View Fuzzy Curves option is selected in the Operations Panel, the user can view the fuzzy curves and the control goes back to the Operations Panel.
b. When the View Fuzzy Sets option is selected the user can view the Fuzzy Sets, view the Fuzzy Curves and then control goes back to the Operations Panel.

c. When the Add Fuzzy Sets option is selected the user can view the Add Fuzzy Sets panel, view the fuzzy curves and then control goes back to the Operations Panel.
d. When the Delete Fuzzy Sets option is selected the user can view the Delete Fuzzy Sets panel where the user can delete the fuzzy set, view the updated fuzzy curves and then control goes back to the Operations Panel.

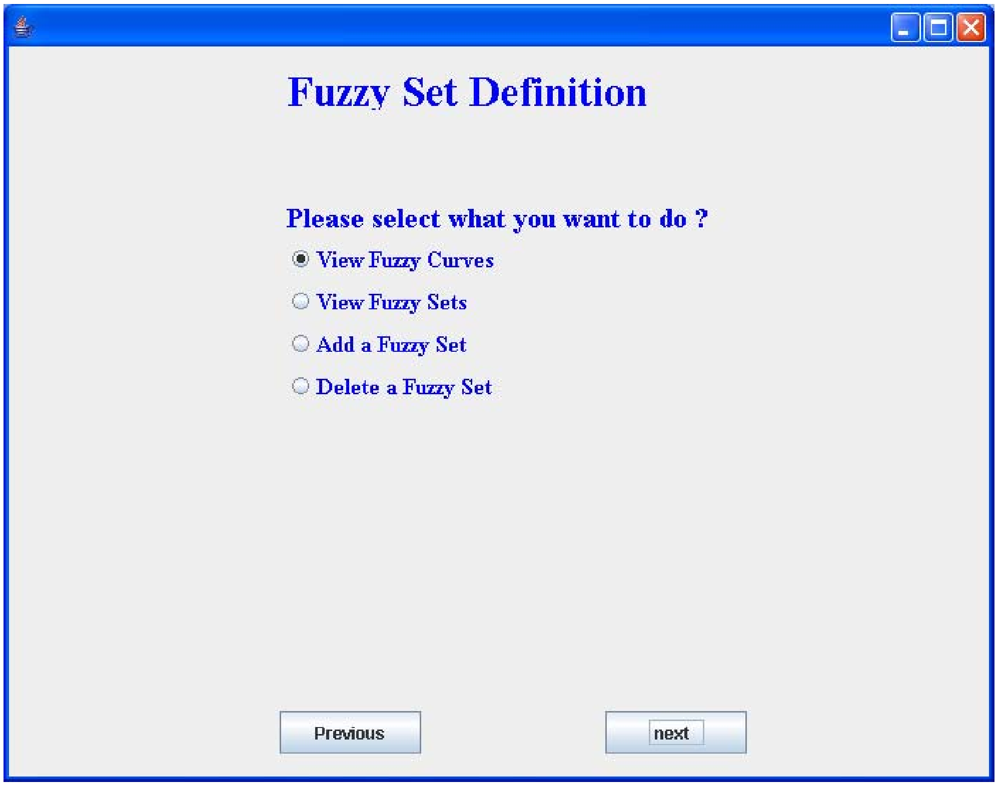


Fig. 2.22. Screenshot of the Fuzzy Set Operations Panel.

Figure 2.23 shows the Fuzzy Curves Input Panel, which shows the fuzzy curves for the selected variable. Users can view the fuzzy curves, parameters and change the membership type to Gaussian by selecting a fuzzy set. Figure 2.24 shows the Fuzzy Sets Input Panel, which contains the fuzzy sets and parameters of the selected variable. The user can modify the fuzzy sets by clicking the “Modify a set” button after changing the parameters. Figure 2.25 shows the Add Fuzzy Set Input Panel where users can add a Fuzzy Set Name with parameters and membership type to the selected variable. Figure 2.26 shows the Delete Fuzzy Set Panel where users can delete a fuzzy set of the selected variable.

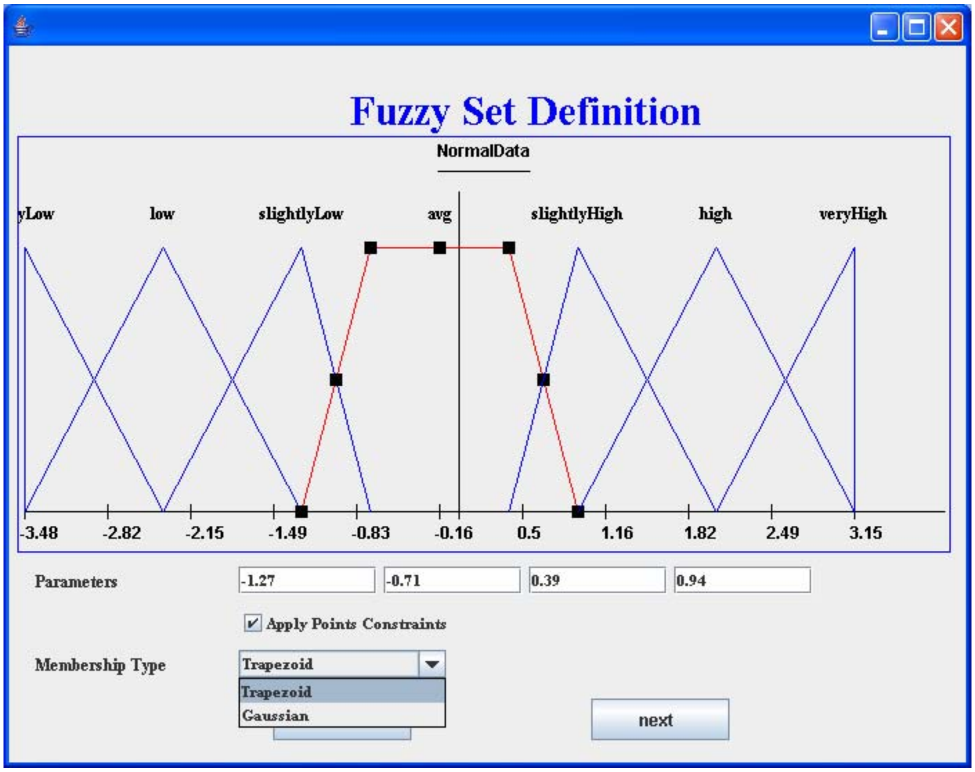


Fig. 2.23. Screenshot of the Fuzzy Curves Input Panel.

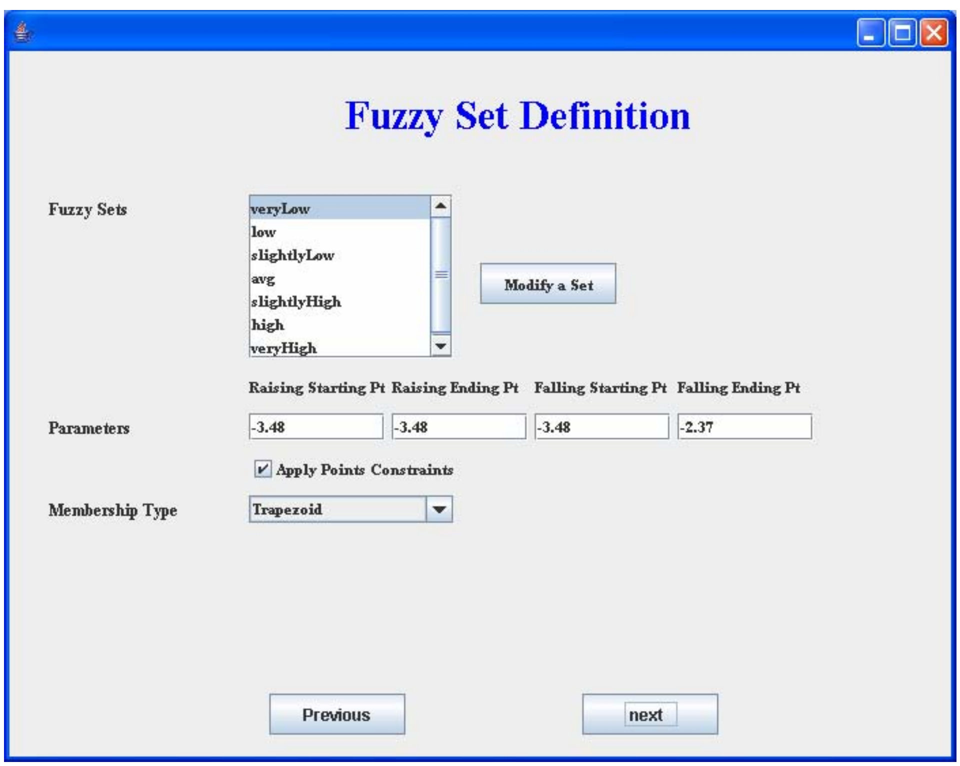


Fig. 2.24. Screenshot of the Fuzzy Sets Input Panel.

Fig. 2.25. Screenshot of the Add Fuzzy Sets Input Panel.

Fig. 2.26. Screenshot of the Delete Fuzzy Sets Input Panel.

Summary - Interfaces to Populate and Manage Knowledge Base Information

A user-friendly tool was developed for the CFS, which allows the user to build the knowledgebase. To integrate this process into the existing CFS software, Java was used as a programming language. The construction of the knowledgebase was identified as an important process of knowledge engineering. The architecture consists of three modules: data cleaning, normality testing, and fuzzy curve generation.

The two stages in which data cleaning is performed were identified as the data collection stage and the data analysis stage. A distance-based algorithm for data cleaning was proposed and analyzed. Subsequently, it was implemented, validated, and integrated into the main project. A K-S test was implemented to test the normality of the data. To give reasoning to a knowledgebase, fuzzy curves are important. The Fuzzy Set Definition algorithms are implemented for both *normal* and *not-normal* data. The fuzzy set definitions for *not-normal* data has four subcases. The fuzzy curves are viewed and modified using the fuzzy curve software. The interpolation algorithms, kriging algorithm and inverse distance weighted algorithms were also implemented.

This software, when implemented with the CFS package of software and wizards will aid in knowledgebase construction using efficient knowledge engineering techniques.

2.3 Data Management Subsystem

This project task involved creating a data management subsystem for the Customizable Fuzzy System (CFS). The data management subsystem for the CFS provides the user with the ability to perform a number of critical operations such as: view, modify, add and search, etc. on a binary data file. The data management subsystem operates on a binary data file (created by another module), which is in a tabular format using user-defined variables/properties, and default data. The integrity of the table format in the binary data file is strictly maintained with the use of white space in every user-defined variable/property of every record. The data management subsystem provides the functionality to add/delete/update a specific column in a binary data file. It also provides the functionality to add/delete/update a specific record in a binary data file. While the core software was largely completed during the first year, it was necessary to create user interfaces and links to wizards for other tasks. Year 2 saw the development of Task 2.1: Expert System Design Wizards.

Binary data formats were selected in response to potential user concerns that they would be forced to use particular relational database software. Noncommercial databases such as MySQL still require licensing fees if used for commercial purposes. In addition, non-commercial software presents a potential security risk that system administrators might find unacceptable. A final concern was updating software versions as a number of different and potentially incompatible releases for public domain software exist which could limit the functional portability of project-developed software.

Binary datafiles are compact and supported by all computer architectures which might use CFS software (computers capable of running a Java Virtual Machine). One issue that needed to be resolved was a method to swiftly search large binary tables. The work presented here represents our solution to that problem. Figure 2.27 shows the main interface screen of the resulting data management subsystem.

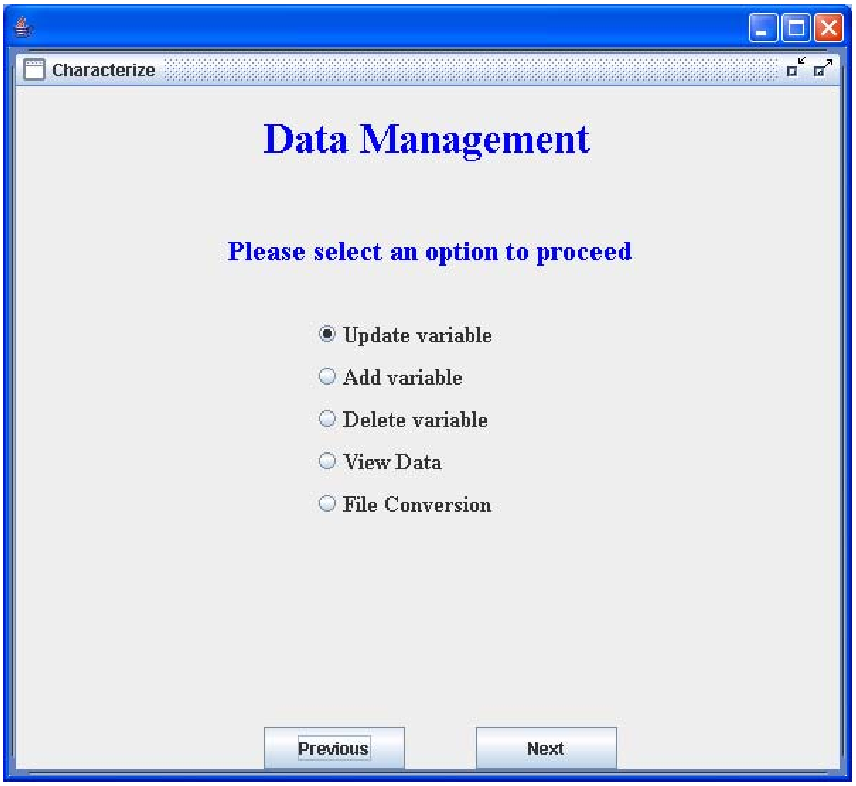


Fig. 2.27. Data management subsystem interface.

The data management subsystem utilizes a modular design. Figure 2.28 shows the architecture of the data management subsystem. The modules of the data management subsystem include the following:

- Data Retrieval Module
- Data Modification Module
- File Conversion Module
- Data Module
- Interface for the Customizable Fuzzy System (CFS)

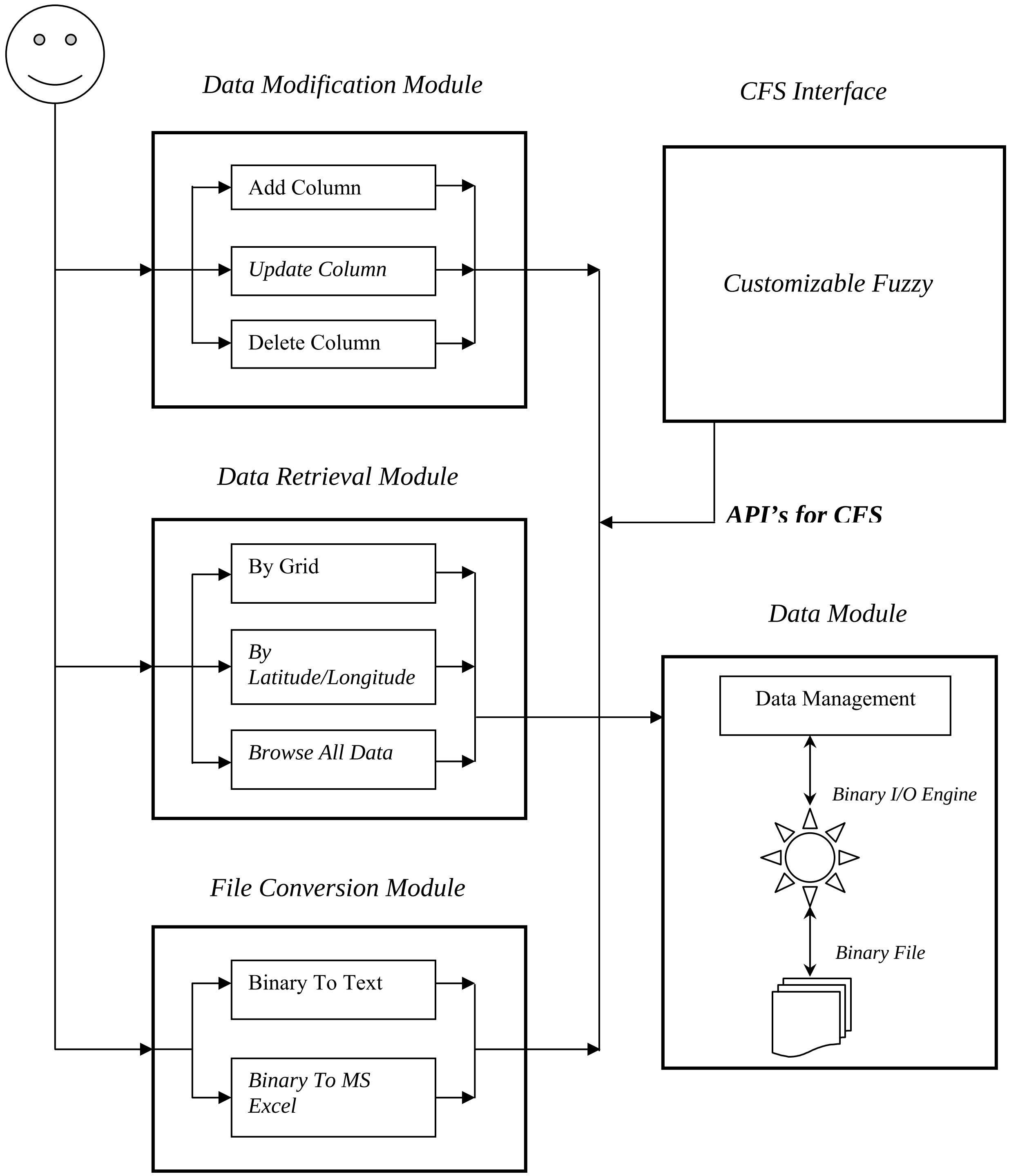


Fig. 2.28. Data management subsystem architecture.

Performance Analysis of the Binary Search Algorithm

Since it was expected that the data file could be very large, exceeding 50,000 records in many cases, searching for a specific record could be very time-consuming, particularly as the use of proprietary database software was precluded for the project. For this purpose a performance analysis, on an existing data set exceeding more than 60,000 records, was carried out using two experiments, sequential search and the binary search algorithm. The goal of this analysis was first to determine how effective the binary search algorithm could be in searching a particular record as compared to a sequential search in the entire binary data file. Second, if the binary search algorithm could reduce the search time significantly, then it should be adopted as the primary search algorithm for the data management subsystem. In both these experiments, the location (latitude and longitude) attributes were used to determine the exact record position of any particular data in the binary data file. In order to compare the results for both methods, a timer was set, which calculated the search time. After analyzing the results of both experiments it was apparent that the binary search algorithm reduced the search time well enough to allow the use of binary data tables in the project.

Sequential Search Experiment and Results: In the first experiment, the entire binary data file was searched sequentially for a particular location. A timer was started just before the search was to be carried out on a particular record in the binary data file. As the record was found the timer stopped and the time for the sequential search was recorded. Average times for three sequential searches for four different locations (latitude/longitude pair) are shown in Fig 2.29.

The results, as expected, were that as the record occurrence in the binary data file continued to increase, the search time also kept on increasing. The record pair 32.01417, -103.625 occurred early in the binary data file, whereas the record pair 32.80995, -103.8722 occurred later in the binary data file. For records sufficiently down the file the search time could be as long as 10 seconds, which was deemed unacceptable.

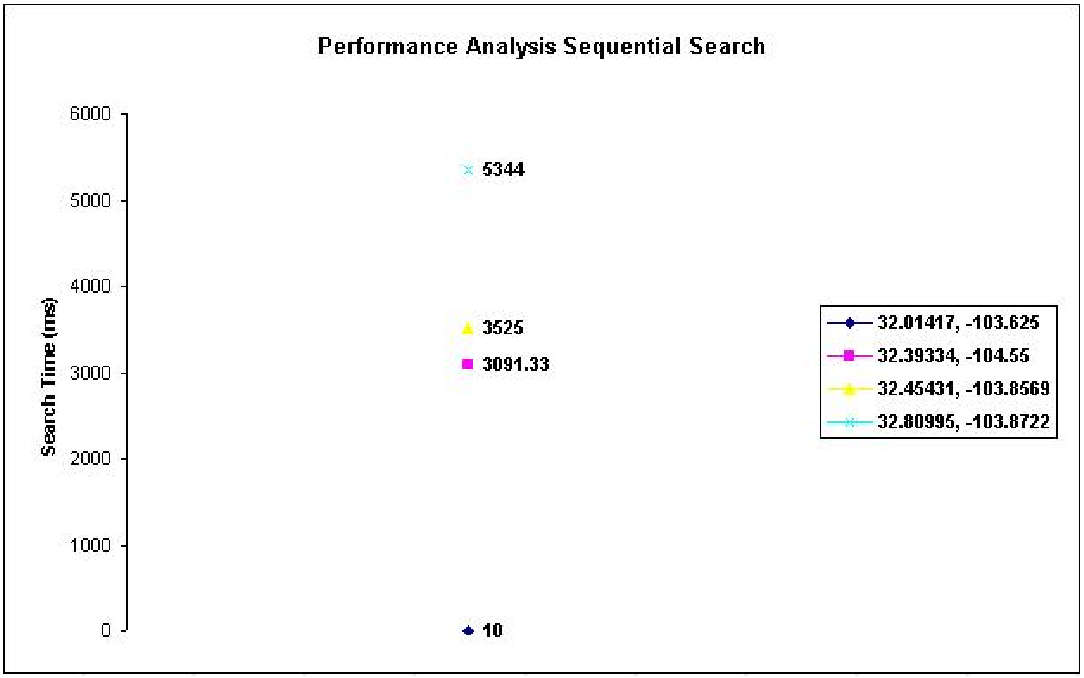


Fig 2.29. Performance analysis sequential search.

Binary Search Algorithm Experiment and Results: In the second experiment, a binary search algorithm was used to search for a particular record. A binary search algorithm is a technique for finding a particular value in a linear array by ruling out half the data at each step (bi-section). It was observed that the binary search algorithm considerably reduced the search time for a particular location. Initially, an index was created on the column "Latitude" of the binary data file. The index was created with two immediate values separated by a gap of 50 values. That is if the latitude values were sequential, starting from 1, then the index values would be 1, 51, 101, 151... and so on. After testing, the index technique, with a gap of 50 between two subsequent values, was found to be the most efficient record finding technique for the data set.

The binary search algorithm works by first determining the latitude range for the requested location within the binary search tree that is created out of the "Latitude"-based index file. Once the latitude range is determined the next step is to find an exact match for the latitude and longitude pair. Doing a sequential search, starting from the first record in the earlier determined latitude range, completes this operation.

In order to test the performance gain compared with the sequential search, a similar experiment was carried out. A timer was started just before the range of the value being searched was determined in the binary search tree. Once this range was determined, a sequential search was carried out for the searched value starting from the first record in the range in the binary data file. As the record was found the timer stopped and the time for the search was recorded. Average times for three searches, using binary search tree for four different locations (latitude/longitude pair), are shown in Fig. 2.30. These locations are the same as those used in the sequential search algorithm test.

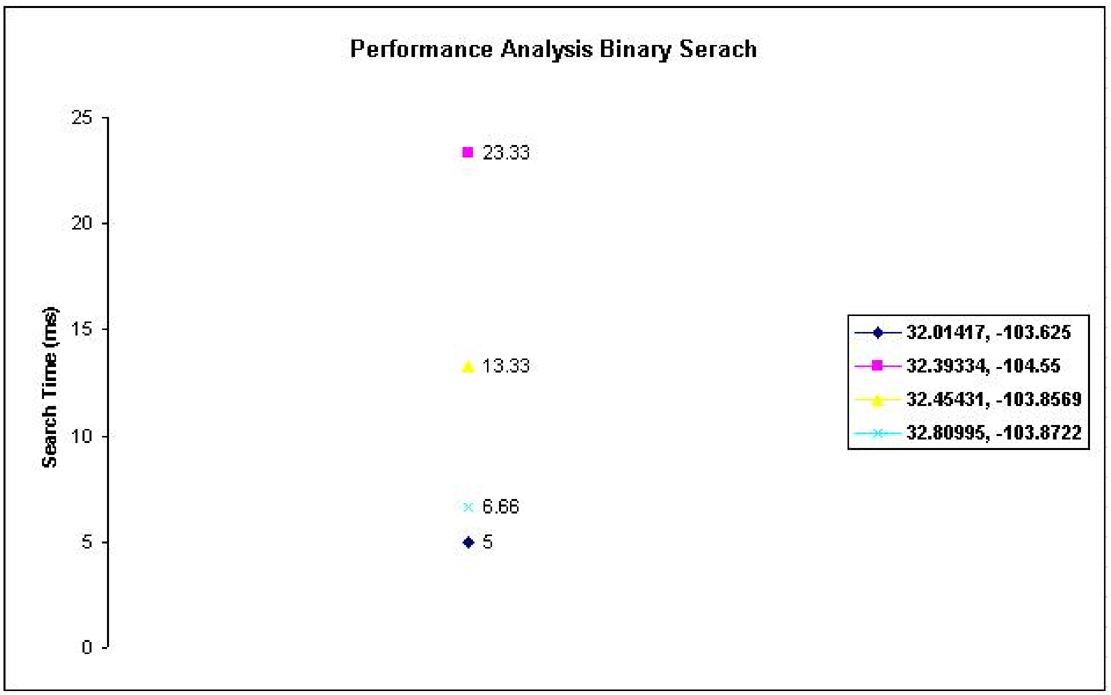


Fig 2.30. Performance analysis binary search.

The above results show that the binary search not only outperforms the sequential search for the problem but that the results were fast enough to justify the binary search algorithm as the primary search algorithm for the data management subsystem. For each CSF binary data file, an index file must be created and maintained as data is added or removed.

Index File Creation and Results: Seven different index files were generated before finally selecting one as the optimized one for the data management subsystem. Binary files of similar sizes should experience roughly similar search times and require roughly similar gaps. This will allow automation of the indexing process for CFS users. The seven different index files were created from the “Latitude” variable/column with a gap of 1, 25, 50, 100, 200, 400 and 800. That is a gap of 25 means that the 1st, 26th, 51st, 76th and so on records are stored in the index file with a gap of 25 between two subsequent values. Figure 2.31 is a screenshot of the index files with block sizes 25, 50, 100 and 800 respectively.

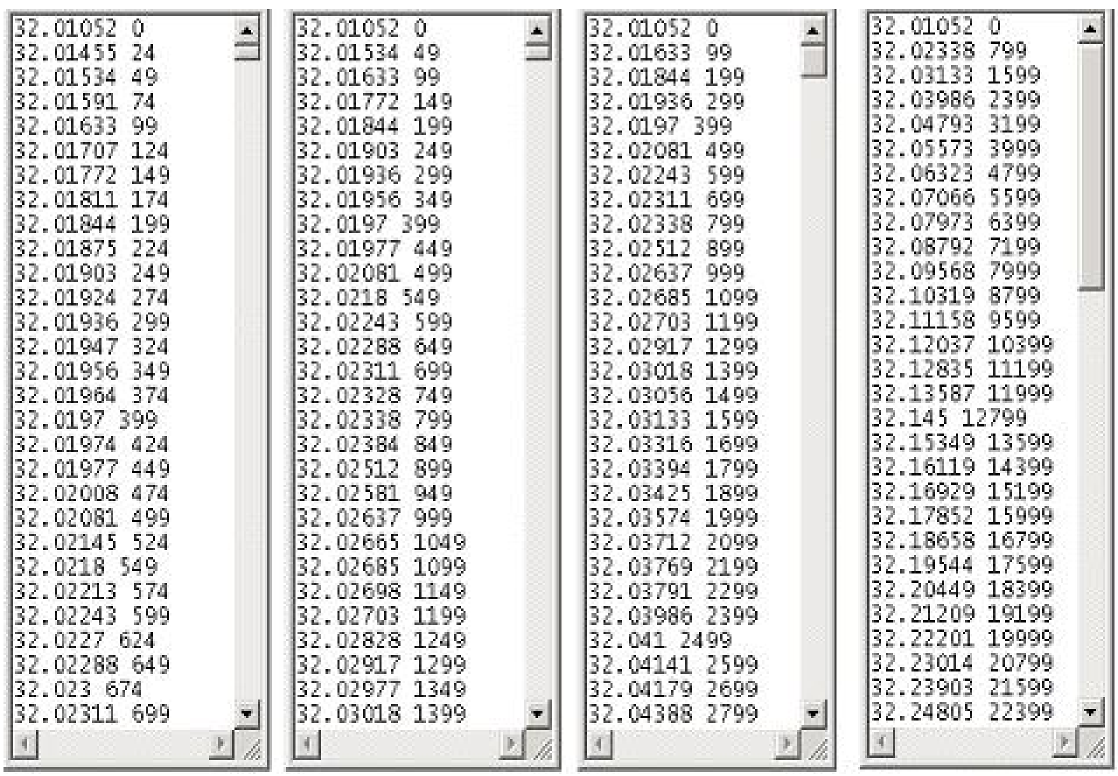


Fig 2.31. Index files with a gap of 25, 50, 100 and 800.

Since the data set on which the data management subsystem has to operate is potentially large, a sequential index file might not work efficiently. The way this process works is to first create a binary search tree for the index values from one of the index files. Starting from the index file, which has a gap of 1, the first step is to determine the range of the latitude value for the data set. A timer is started just before the range of the latitude value, from the latitude/longitude pair, is determined in the binary search tree. Once this range is determined, a sequential search is carried out for the searched value starting from the first record in the range in the binary data file. As the record is found the timer stops and the time for the search is recorded.

Several experiments were conducted on different latitude/longitude pair values from the binary data file. Three tests were conducted on a particular latitude/longitude pair and the time it took to search a record in the binary data file using all of the seven index files was recorded. Thus, for a particular value, 21 tests were conducted. Then the average of the three tests was calculated for a particular index file to determine the time it takes to search a record in the binary data file. Below is a graph showing the time taken to search latitude/longitude pair values (32.01417, -103.625), (32.39334, -104.55) and (32.80995, -103.8722) for all the seven sparse index files.

It was observed that for the index file having block sizes 50 the search time was the minimum. That led to the selection of the index file having block size 50 as the primary index file for the data management subsystem, as shown in Fig 2.32.

The data management subsystem also provides the user the ability to convert the binary data file to text (.txt) format. The file conversion makes it possible to export data for use outside the data management subsystem. On initiation, the data management subsystem is provided with a binary data file generated by a separate wizard in another module. For better data integrity, the oil reservoir data is stored in a binary format. A snapshot of the data file on which the data management subsystem operates is shown in Fig 2.33. Each column in the data file represents a variable in the data management subsystem. The data management subsystem operates on these columns by performing different operations on them.

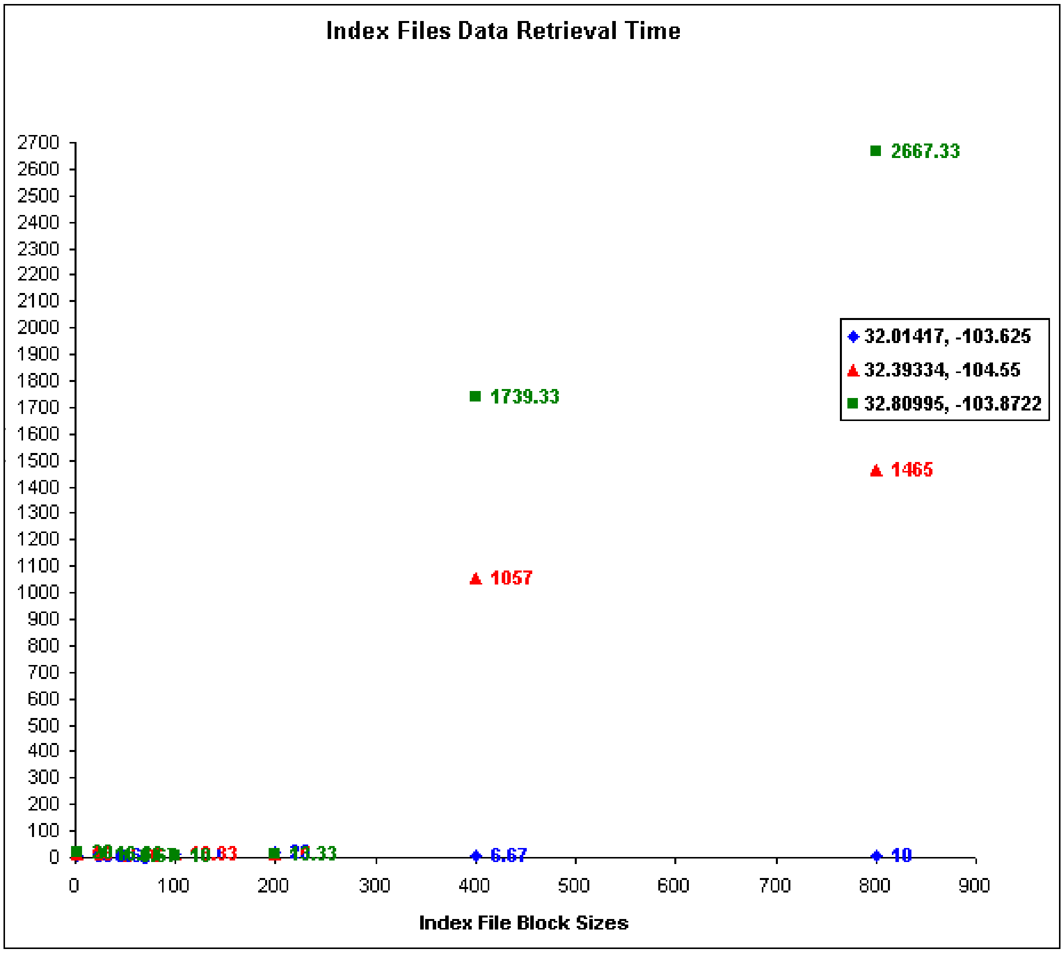


Fig. 2.32. Index files search time for different set of values.

165479.78	-3239.9	-5152.0	....	4.533239	500
149463.41	-3810.9	-5152.0	....	13.115721	500
141314.0	-4172.5	-5152.0	....	1.1265149	500
134458.7	-4714.0	-5152.0	....	0	500
126994.7	-5340.3	-5152.0	....	0	500
114322.97	-5878.5	-5152.0	....	0	500
108441.03	-5933.9	-5152.0	....	0	500
103500.12	-5989.2	-4638.1	....	0	1500
93001.471	-6028.2	-4638.1	....	0	1500

Fig. 2.33. Data management subsystem, binary data file.

The initial format of the columns of the binary file, in each row/record, is shown in Table 2.12. The first five columns in Fig 2.34 are specific to the location of a reservoir. These five columns are not a part of the snapshot in Fig 2.33.

Table 2.12. Data Management Subsystem, Binary File Format

Column-Name	**Data Type**	**Size in Bytes**
	Int	4
X-Coordinate	Int	4
Y-Coordinate	Int	4
Latitude	Double	8
Longitude	Double	8
MinDistance	Double	8
DepthAtProspect	Double	8
DepthAtNearestWell	Grid#	8
. .	. .	. .
STDDeviation	Double	8
HighPredProd	Double	8

Each row in the binary data file is a complete record of all associated values with a particular location. After the user modifies, adds, deletes, or updates any column of the data file, through the data management subsystem, the size of a record in each row changes accordingly. The overall effect is to alter the size of the file; a representative file used for development purposes contains more than 60,000 records and occupies approximately 12MB of disk space.

Data Retrieval Module

The Data Retrieval module of the data management subsystem lets the user retrieve data from the data file on the basis of supplied parameters. There are different ways through which data can be retrieved. The view data screen (Fig 2.34) gives the user three choices to retrieve and display the data. The three options are: **By Grid, By Latitude** / **Longitude** and **Browse All Data.** When the user selects any of these options, the requisite controls are enabled and the others are disabled.

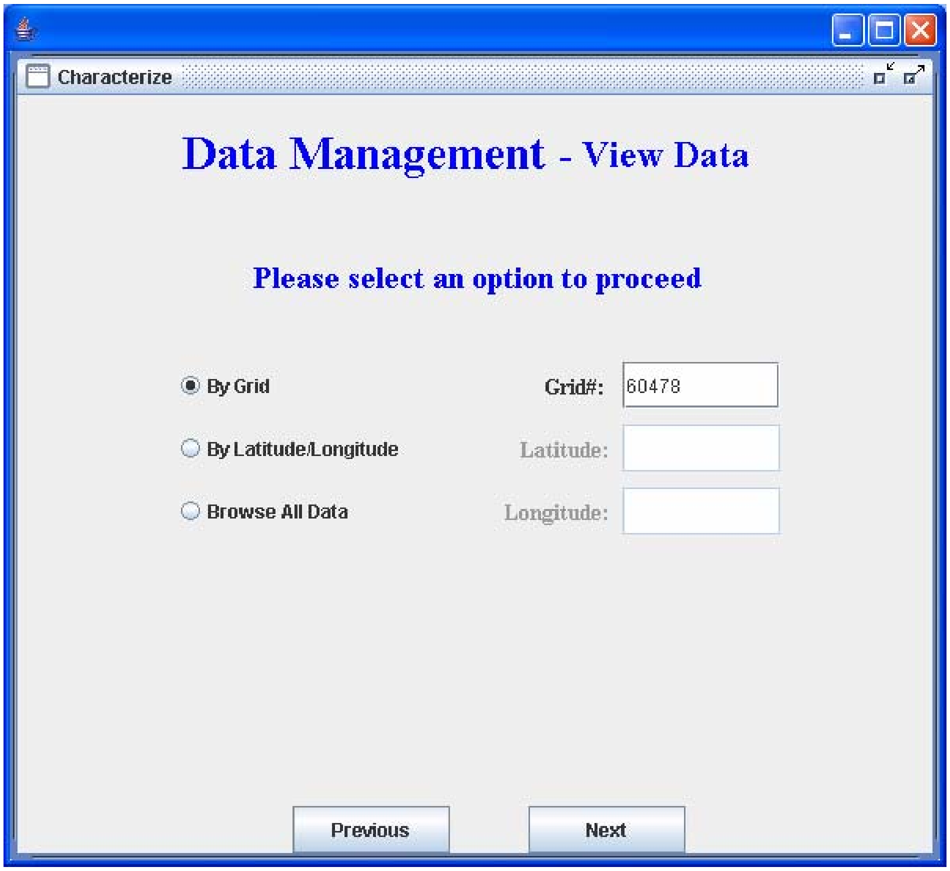


Fig 2.34. Data Retrieval module, By Grid option.

In Fig 2.34 the radio button to view the data on the basis of Grid# is selected. Now the user can enter the Grid# (as shown) before pressing the Next button. If data corresponding to the Grid# is available, the entire row/record will be displayed as in Fig 2.35, otherwise an appropriate message regarding the data unavailability will be displayed. The user can also choose to examine the data using the latitude and longitude values of the reservoir. In Fig 2.36 the user has selected to view the data using the latitude/longitude pair 32.01052/-103.1395.

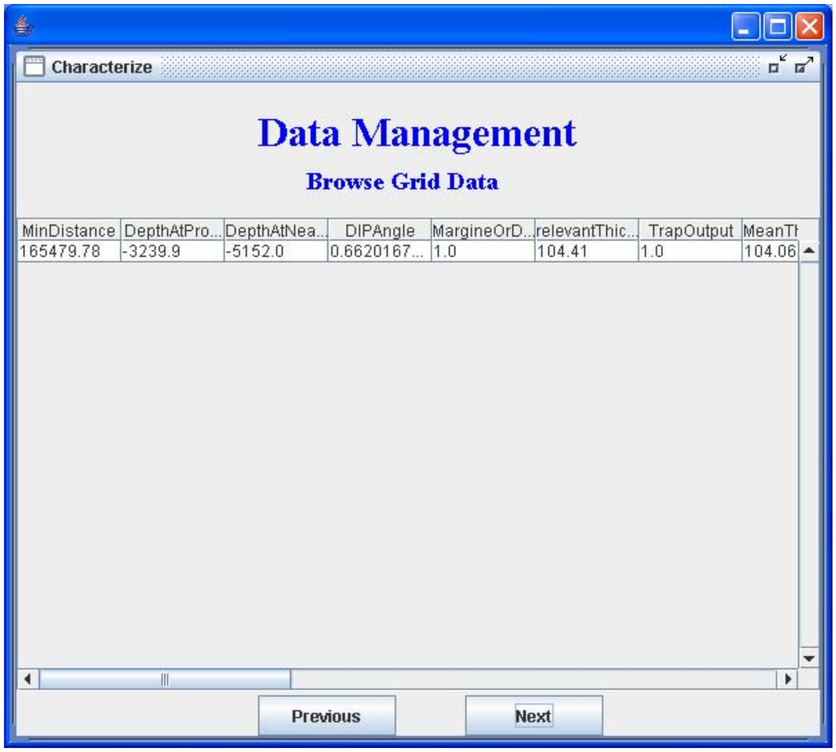


Fig. 2.35. Data Retrieval module output.

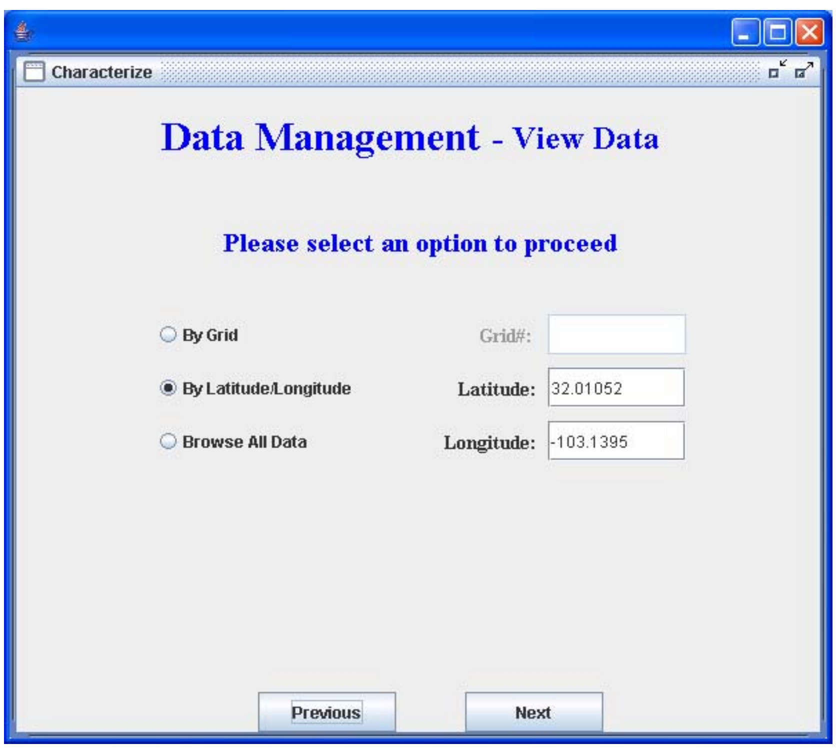
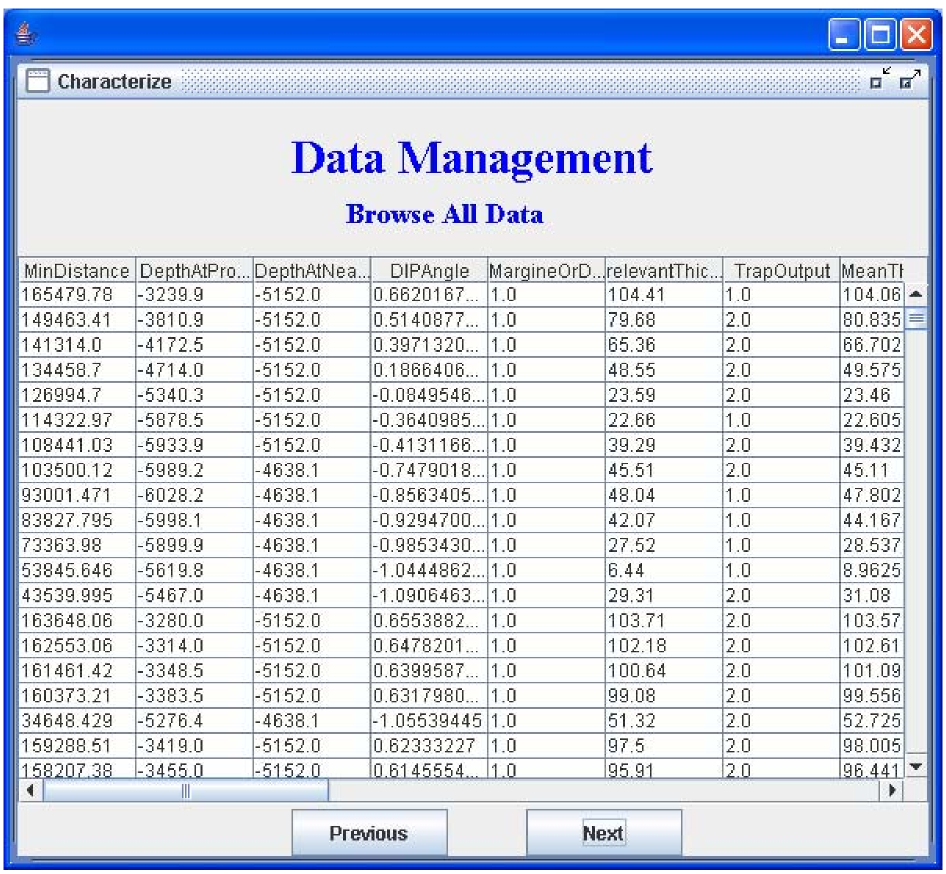


Fig. 2.36. Data Retrieval module, By Latitude/Longitude option.

The user can also elect to examine the entire data file at once using the “Browse All Data” option. The Browse All Data option is currently being re-implemented using Java pipe and thread concepts to optimize load times. The entire process is averaging 30–60 seconds depending on hardware. This is understandable as fetching the entire data set from the binary data file (60,000 records test data) is quite an enormous task. However, after the implementation of the pipe and thread concepts, the data should be retrieved much faster. Initially, the main application thread first retrieves the first 100 records. At that point a pipe is created. On the receiving end of the pipe is the main application, waiting for the next chunk of records (100 or less records). On the other end of the pipe another thread is created that sequentially requests the next chunk of 100 records (from the Data module) until the entire binary data file gets exhausted and all the records are retrieved. Figure 2.37 shows the screens through which the data is displayed using the Browse All Data option.



MinDistance	DepthAtPro...	DepthAtNea...	DIPAngle	MargineOrD...	relevantThic...	TrapOutput	MeanTl
165479.78	-3239.9	-5152.0	0.6620167...	1.0	104.41	1.0	104.06
149463.41	-3810.9	-5152.0	0.5140877...	1.0	79.68	2.0	80.835
141314.0	-4172.5	-5152.0	0.3971320...	1.0	65.36	2.0	66.702
134458.7	-4714.0	-5152.0	0.1866406...	1.0	48.55	2.0	49.575
126994.7	-5340.3	-5152.0	-0.0849546...	1.0	23.59	2.0	23.46
114322.97	-5878.5	-5152.0	-0.3640985...	1.0	22.66	1.0	22.605
108441.03	-5933.9	-5152.0	-0.4131166...	1.0	39.29	2.0	39.432
103500.12	-5989.2	-4638.1	-0.7479018...	1.0	45.51	2.0	45.11
93001.471	-6028.2	-4638.1	-0.8563405...	1.0	48.04	1.0	47.802
83827.795	-5998.1	-4638.1	-0.9294700...	1.0	42.07	1.0	44.167
73363.98	-5899.9	-4638.1	-0.9853430...	1.0	27.52	1.0	28.537
53845.646	-5619.8	-4638.1	-1.0444862...	1.0	6.44	1.0	8.9625
43539.995	-5467.0	-4638.1	-1.0906463...	1.0	29.31	2.0	31.08
163648.06	-3280.0	-5152.0	0.6553882...	1.0	103.71	2.0	103.57
162553.06	-3314.0	-5152.0	0.6478201...	1.0	102.18	2.0	102.61
161461.42	-3348.5	-5152.0	0.6399587...	1.0	100.64	2.0	101.09
160373.21	-3383.5	-5152.0	0.6317980...	1.0	99.08	2.0	99.556
34648.429	-5276.4	-4638.1	-1.05539445	1.0	51.32	2.0	52.725
159288.51	-3419.0	-5152.0	0.62333227	1.0	97.5	2.0	98.005
158207.38	-3455.0	-5152.0	0.6145554...	1.0	95.91	2.0	96.441

Fig. 2.37. Data Retrieval module, All Data result.

Data Modification Module

The Data Modification module is an important part of the data management subsystem for the CFS that allows users to make and save changes to the data file for their projects.

Add Variable/Column: The Add Variable/Column functionality provides the user with the ability to add more variables/columns to the existing data management subsystem binary data file. The effect resembles the addition of an attribute to an existing table in a relational database at run-time. A drop-down list of all the variables/columns along with their data types is pulled from a look-up file generated by another module. Only those variables/properties that are not a part of the current binary file are displayed in the drop down list of the Add Variable/Column module. If the user wants to add another column to the data file structure then the Add Variable option is selected on the main screen (Fig. 2.38). This will take the user to the Add Variable main screen as shown in Fig 2.39.

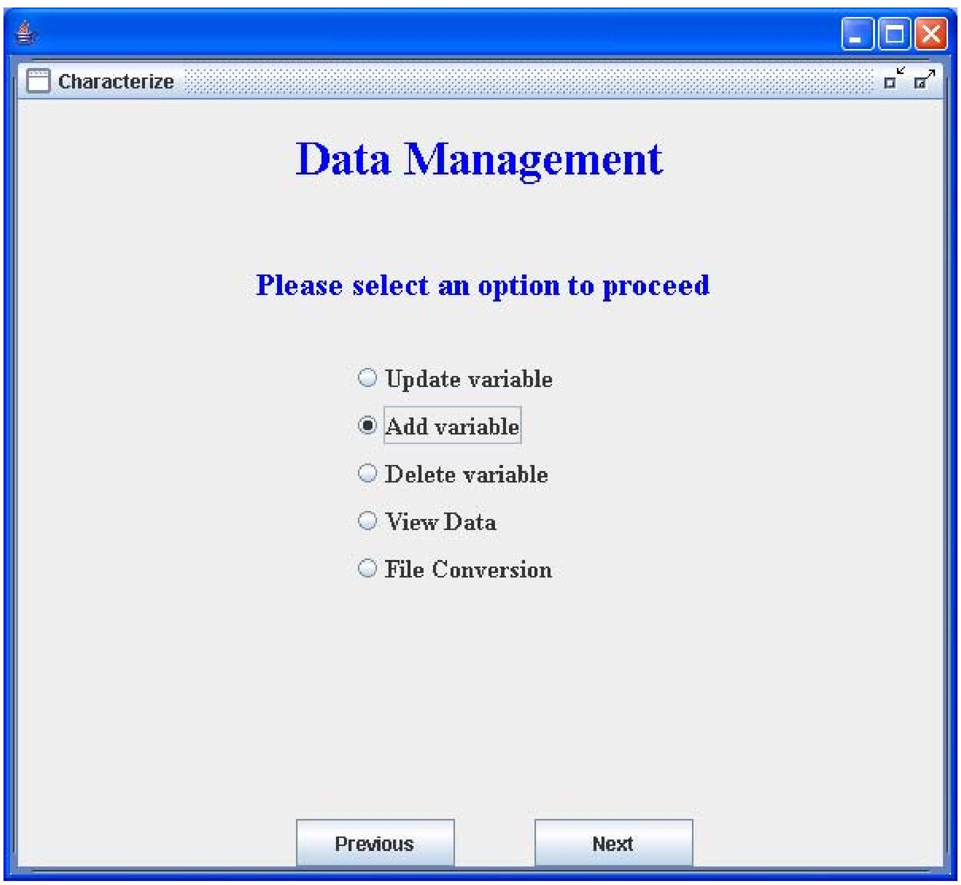


Fig. 2.38. Data Modification module, Add Variable option.

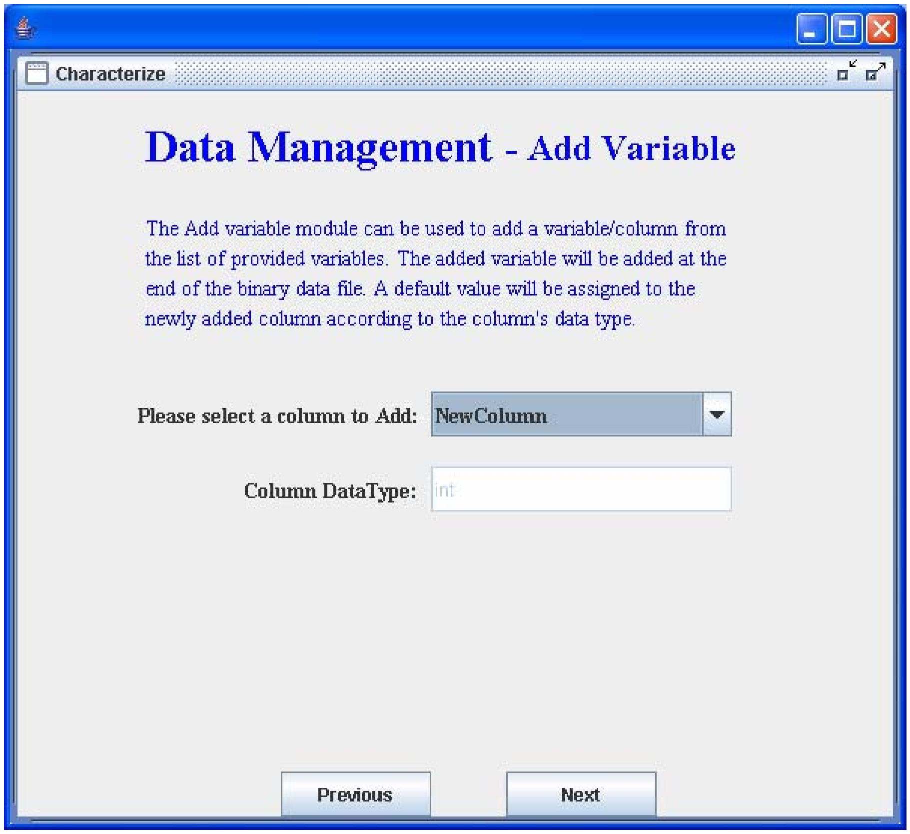


Fig. 2.39. Data Modification module, Add Variable screen.

In Fig 2.39 the user has elected to add the column "NewColumn" with data type "int". After the user presses the Next button the data file's initial data and format (Fig 2.33 and Table 2.12) change to that shown in Fig 2.40 and Table 2.13 respectively.

***NewColumn**: default value -99999*

165479.78	-3239.9	-5152.0	....	4.533239	500	-99999
149463.41	-3810.9	-5152.0	....	13.115721	500	-99999
141314.0	-4172.5	-5152.0	....	1.1265149	500	-99999
134458.7	-4714.0	-5152.0	....	0	500	-99999
126994.7	-5340.3	-5152.0	....	0	500	-99999
114322.97	-5878.5	-5152.0	....	0	500	-99999
108441.03	-5933.9	-5152.0	....	0	500	-99999
103500.12	-5989.2	-4638.1	....	0	1500	-99999
93001.471	-6028.2	-4638.1	....	0	1500	-99999

Fig. 2.40. Data management subsystem, binary data file after Add.

Table 2.13. Data Management Subsystem, Binary File Format after Add

Column-Name	***Data Type***	***Size in Bytes***
Grid#	*Int*	*4*
X-Coordinate	*Int*	*4*
Y-Coordinate	*Int*	*4*
Latitude	*Double*	*8*
Longitude	*Double*	*8*
MinDistance	*Double*	*8*
DepthAtProspect	*Double*	*8*
DepthAtNearestWell	*Double*	*8*
. . .	. . .	. . .
STDDeviation	*Double*	*8*
HighPredProd	*Double*	*8*
NewColumn	*Int*	*4*

Update a Variable/Column: If the user wants to update the data contained within a column to the data file structure *Variable* then the user would select the Update Variable feature on the main screen (Fig. 2.41) before pressing the Next button. This functionality provides the user with a drop-down list of all the variables/columns that are currently available in the binary data file. In the Update variable screen, the user is prompted to select a column from the drop-down list before pressing the Next button. In Fig. 2.42 the user has selected the column "MinDistance" for updating.

The next screen is the data file selection screen (Fig. 2.43). The user in this case selects a text file whose data values need to be updated in the main binary data file. This text file can contain any number of records ranging from 1 to the maximum record size of the binary file. After the user makes this selection the data management module processes the request and the data in the binary data file is updated for the corresponding records in the text file. The system alerts the user by displaying an appropriate message that the modifications are completed.

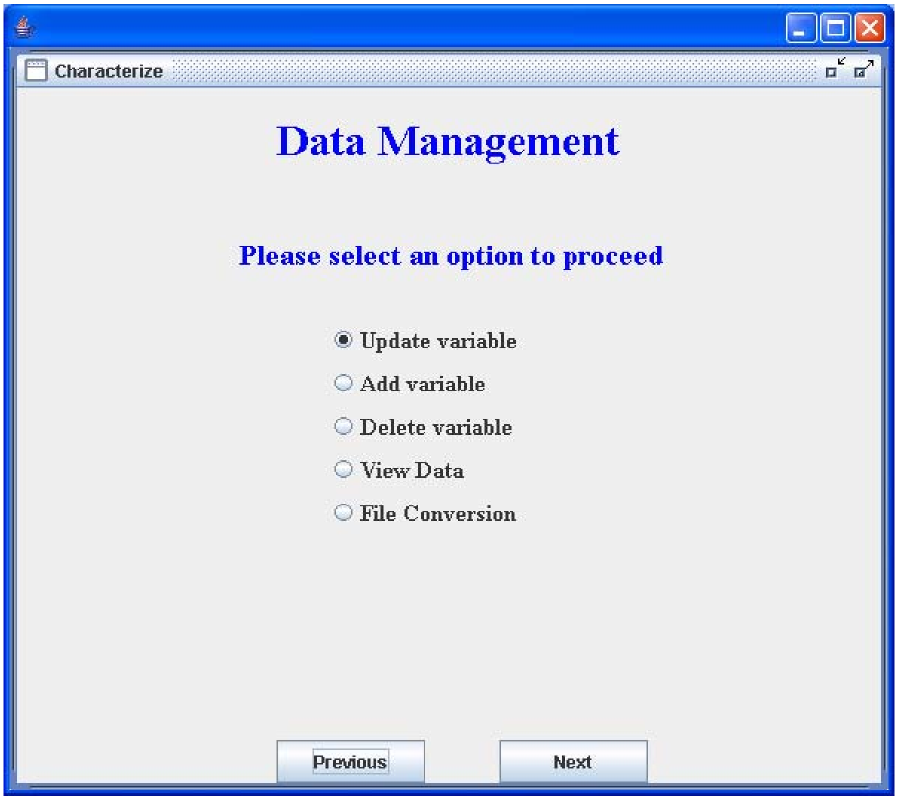


Fig. 2.41. Data management subsystem, Update option.

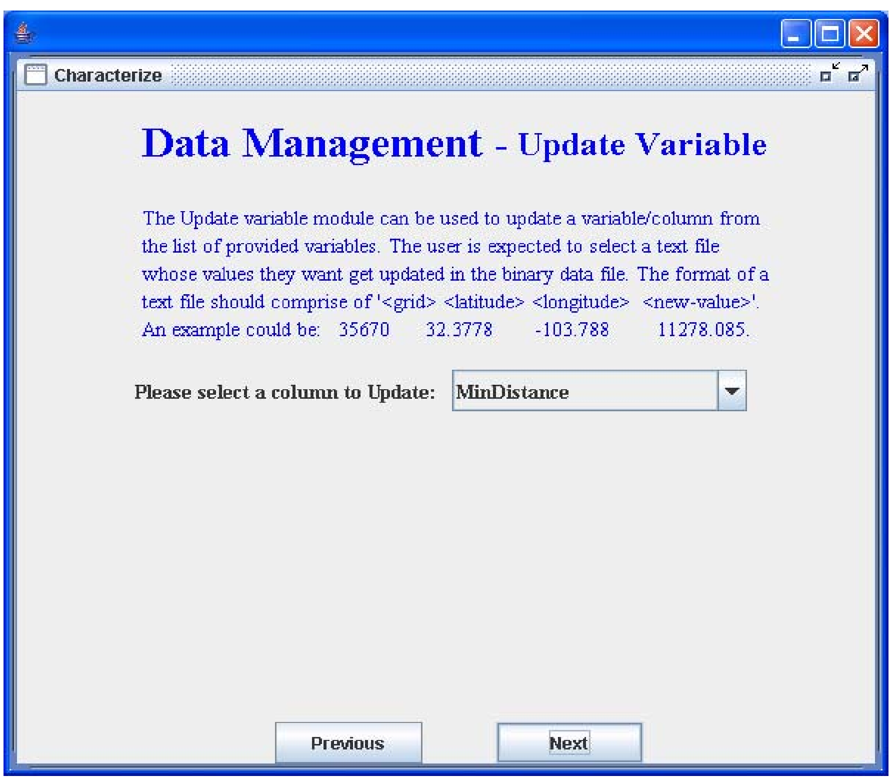


Fig. 2.42. Data management subsystem, Update Variable screen.

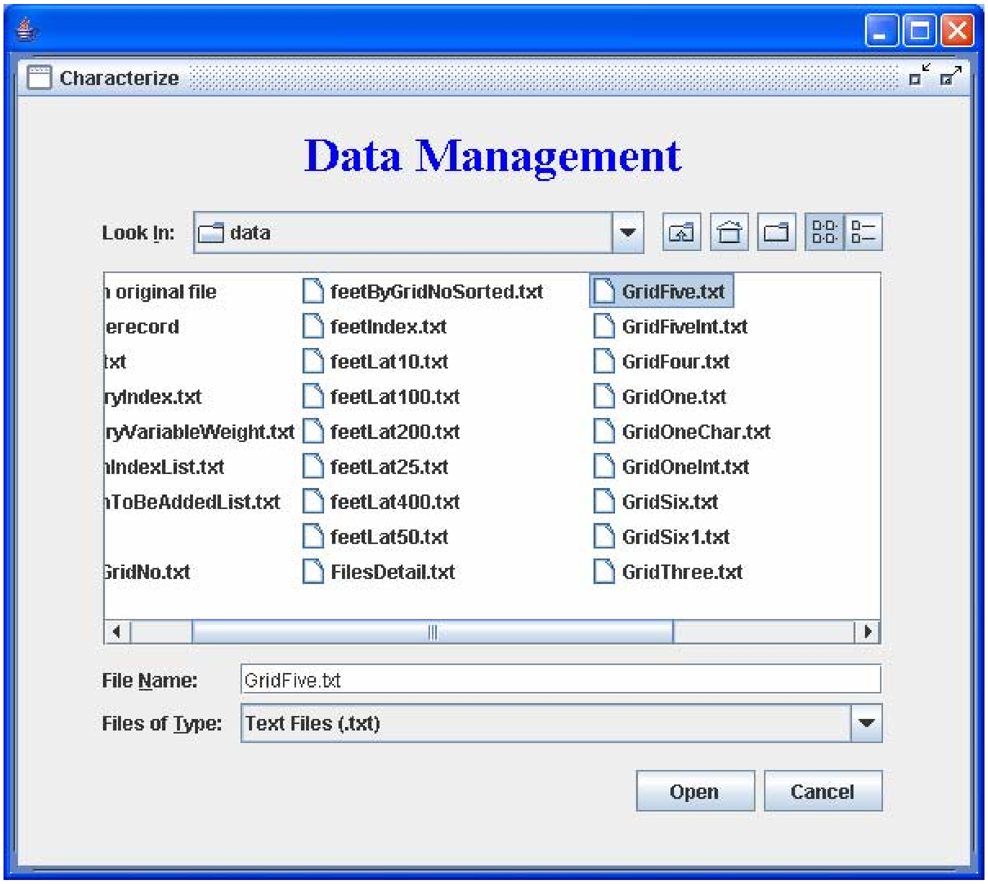


Fig. 2.43. Data management subsystem, Data File Selection.

Delete a Variable/Column: If the user wants to delete a column from the binary data file structure then the user would select the Delete Variable option on the main screen before pressing the Next button. In the Delete Variable main screen the user then selects a column that is to be deleted from the list of provided columns. When the user presses the Next button, the column is deleted and the user is notified about the modification. In Fig. 2.44 the user wants to delete the column “DepthAtProspect”. After the user presses the Next button, the data file’s data and format are changed to those shown in Fig. 2.45 and Table 2.14 respectively.

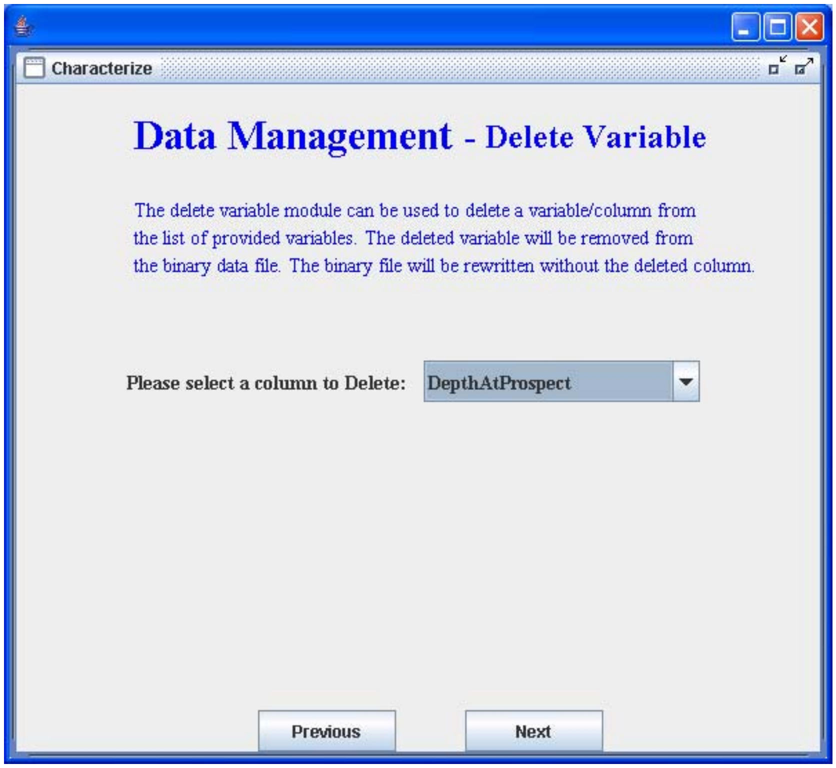


Fig. 2.44. Data management subsystem, Delete Variable screen.

165479.78	-5152.0	....	4.533239	500	-99999
149463.41	-5152.0	....	13.115721	500	-99999
141314.0	-5152.0	....	1.1265149	500	-99999
134458.7	-5152.0	....	0	500	-99999
126994.7	-5152.0	....	0	500	-99999
114322.97	-5152.0	....	0	500	-99999
108441.03	-5152.0	....	0	500	-99999
103500.12	-4638.1	....	0	1500	-99999
93001.471	-4638.1	....	0	1500	-99999

Fig. 2.45. Data management subsystem, binary data file after Delete.

Table 2.14. Data Management Subsystem, Binary File Format after Delete

Column-Name	***Data Type***	***Size in Bytes***
Grid#	*Int*	*4*
X-Coordinate	*Int*	*4*
Y-Coordinate	*Int*	*4*
Latitude	*Double*	*8*
Longitude	*Double*	*8*
MinDistance	*Double*	*8*
DepthAtNearestWell	*Double*	*8*
. . .	. . .	. . .
STDDeviation	*Double*	*8*
HighPredProd	*Double*	*8*
NewColumn	*Int*	*4*

File Conversion Module

The data management subsystem includes the function of converting the main binary data file to a text file (Figs. 2.46 and 2.47). this allows export of data into other programs, such as excel or a relational database.

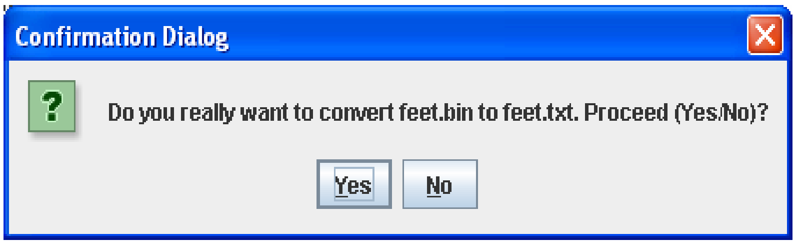


Fig. 2.46. Binary to text conversion—Confirmation Dialog.

Fig. 2.47. Binary to text conversion—Notification Dialog.

Data Module Summary

The Data Module is local to the data management subsystem. It is not accessible from outside the data management subsystem. Only the Data Retrieval, Data Modification, File Conversion and Interface for the Customizable Fuzzy System modules can access the Data Module. It is generally expected the database will be populated automatically and the only need of a user would be to remove or add specific data streams. Wizards to accomplish these tasks will be available for less computer-savvy users.

Interface for the Customizable Fuzzy System (CFS): The data management subsystem is an independent application. However, the data management subsystem is developed for data management of the CFS. There has to be a means through which the CFS can communicate with the data management subsystem. For this purpose, APIs (application programming interfaces) have been designed to allow communication with the CFS.

Summary—Data Management Subsystem

The data management of the drilling data, a core component of the CFS, requires robust implementation for the success of the CFS. The data management subsystem, with its user interface, provides a platform from where operations on the CFS's binary data are performed efficiently and accurately. The binary data file is kept in a tabular format using user-defined variables/properties and default data. In order to maintain the integrity of the entire binary data file, white space is used in every user-defined variable/property of every record. The data management subsystem is designed in different modules where a particular functionality is restricted to that specific module.

The data management subsystem with all the current features in place is working as expected. The data retrieval module retrieves and displays the data for the requested grid#, latitude/longitude pair and the entire data file successfully.

The data modification's Add Variable/Column module successfully lists the columns that are not part of the data management system's existing binary data file. Once the user selects to add a particular column that column with its data type is added to the entire binary data file with a default value. The Update Variable/Column functionality updates a particular variable/column of the binary data file. The functionality accomplishes the task by first allowing the user select a variable/column from an existing binary data file. Second, the functionality allows the user to select a text file whose values need to be updated in the main binary data file. An appropriate message, confirming the modifications are complete, describes the success of the functionality. The Delete Variable/Column module successfully processes the user request and deletes a variable/column specified by the user from the entire binary data file.

The file conversion module successfully converts the data management subsystem's entire binary data file into a text file. The success of the module is verified by comparing the original text file with the text file generated by the file conversion module.

The data module, internal to the data management subsystem, deals with all the processing on the binary data file requested by the data retrieval, data modification and file conversion modules. The module is verified with the successful working of the data retrieval, data modification and file conversion modules.

The interface for the CFS is tested by integrating the data management subsystem with the entire customizable fuzzy system. All the data management subsystem's modules work as specified with the customizable fuzzy system after the integration.

2.4 Acquiring and Converting Mapped Data

The knowledgebase is built using the pre-existing answer base for play type, user provided data at specific locations and interpolated user provided data. An important feature is the ability to assimilate digital map data and to map both input data and CFS results. Figure 2.48 illustrates how the CFS utilizes digitally mapped data in the construction of a knowledgebase utilizing user-provided data interpolated over a geographic region. Addition of Wizard-based software for processing such data and requests is scheduled for the third project year. The algorithm development and associated code was completed in the second project year.

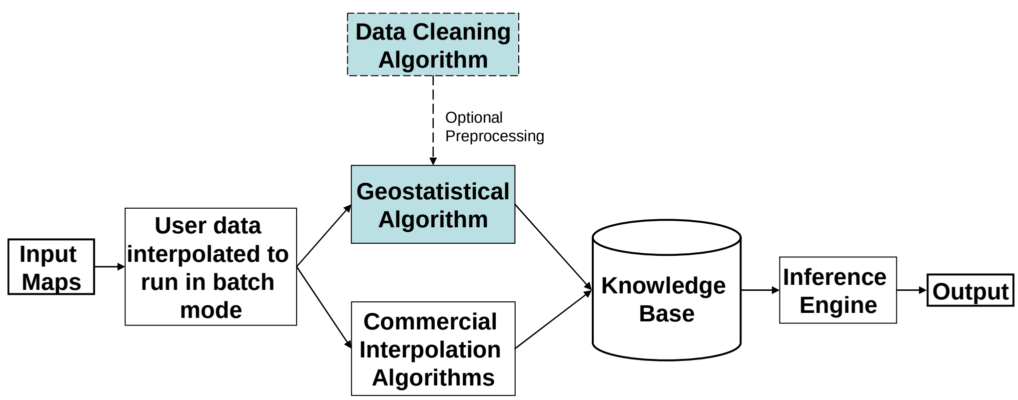


Fig. 2.48. Use of map data in knowledgebase generation for the CFS.

Geostatistical Analysis

The geostatistical algorithms—ordinary kriging and Inverse Distance Weighted (IDW)—were developed to interpolate the unknown values over the region based on the measured values at the specified locations. The IDW algorithm works by calculating the influence of a measured value on a grid point as a function of its distance. The kriging algorithm considers the spatial autocorrelation of the data by looking at the variogram, and uses properties of the variogram to calculate the weights. The weights, in turn, are used to calculate the values at the grid points.

In this tool, the IDW method is recommended when the input data consists of more than 30 locations. The Data Cleaning module is available for preprocessing this data prior to interpolating.

The first steps in the geostatistical algorithms are the same for either method, and involves reading in the user's values and then setting up the grid. A rectangular grid is used for this code, and can be set by default to be the minimum rectangle based on the user's data, or can be adjusted to any desired size. This allows the user to set up one grid for the entire process, and repeat the gridding algorithm on various variables to come up with one answer base.

Variables xk and yk should be in feet or meters; this makes a difference in the bin setup in the ordinary kriging algorithm. K total is the number of known points, zk is the measured value at the point (xk, yk) and can be any measured value in a variety of units (e.g. porosity, permeability, gas production, TOC). If $K > 30$, IDW is used, otherwise ordinary kriging is used.

The output grid is designed with six parameters:
xmin, xmax (the default here can be the smallest and largest xk values)
ymin, ymax (the default here can be the smallest and largest yk values)
xnum, ynum: number of cells in the x and y directions

xstep, ystep: dimensions (size) of the cell, which is calculated as follows:

$$xstep = \frac{x\max - x\min}{xnum}$$

$$ystep = \frac{y\max - y\min}{ynum}$$

Inverse Distance Weighted (IDW): The Inverse Distance Weighted algorithm calculates the z values at a location using the inverse distance weight measure. Figure. 2.49 describes the algorithm that interpolates the values of z value (i,j) for the given number of cells in x and y direction using the inverse distance weights. The values of xk, yk and zk are provided in the input file.

```
for i = 0 to xnum-1 do
   for j = 0 to ynum-1 do
      xcoordinate(i,j) = xmin + i*xstep
       ycoordinate(i,j) = ymin + j*ystep
      sumw = 0
      for ik = 1 to K do
```

$$DistK(ik) = \sqrt{(xcoordinate(i,j) - xk(ik))^2 + (ycoordiante(i,j) - yk(ik))^2}$$

$$w1(ik) = \frac{1}{DistK(ik)^2}$$

$$sumw = sumw + w1(ik)$$

```
            next
      zvalue(i,j) = 0
       for ik = 1 to K do
```

$$weight(ik) = {w1(ik)}/{sumw}$$

$$zvalue(i,j) = zvalue + weight(ik) * zk(ik)$$

```
            next
      next
next
```

Fig. 2.49. Algorithm: Inverse Distance Weighted (IDW).

Ordinary Kriging: This is a quick kriging algorithm, with a variogram calculated from a pre-defined set of bins and then fit with a simple estimate to get a value for sill, nugget and range. The sill, nugget and range values are then plugged into an exponential equation to calculate the C matrix between each pair of measured data. The matrix is then inverted and multiplied by the vector of covariance using distances from the gridpoint to the known data. This produces the weights, which are then normalized and applied as in the previous algorithm.

1. Calculate distances between data points:

```
for i = 1 to K do
     for j = 1 to K do
```

$$DK(i,j) = \sqrt{(xk(i) - xk(j))^2 + (yk(i) - yk(j))^2}$$

```
               next
          next
```

2. Bin data and compute points for a variogram:

a. Find max of the DK(i,j) to get the upper bound for the bins

```
MaxDK = 0
for i = 1 to K do
   for j = 1 to K do
         if DK(i,j) > MaxDK
         then MaxDK = DK(i,j)
     next
next
```

b. Calculate the number of bins and the binned variogram output:

```
lag_ft = 5000
binnumber = roundup(MaxDK/lag_ft)
for m = 1 to binnumber do
```

```
    H(m)=(lag_ft/2)+(m-1)(lag_ft)
    vardiff = 0
    for i = 1 to K do
       for j = 1 to K do
          if (m-1)(lag_ft) ≤ DK(i,j) < m(lag_ft)
          then N(m) = N(m) +1
          vardiff = (zk(i)-zk(j))^2 + vardiff
                         next
                    next
     gamma(m) = 1/(2N(m)) * vardiff
next
```

c. Estimate sill, range and nugget:

```
sum = 0
  for m = 1 to binnumber do
     sum = sum + gamma(m)
  next
  meangamma = sum/binnumber
  stsum = 0
  for m = 1 to binnumber
     stsum = (gamma(m) - meangamma)^2 + stsum
next
  ssqr = stsum/(binnumber - 1)
  stdevgamma = √(ssqr)
  maxgamma = 0
  for m = 1 to binnumber do
          if gamma(m) > maxgamma
     then maxgamma = gamma(m)
          next
  if maxgamma < meangamma + 2* stdevgamma
   then sill = maxgamma
```

```
else sill = meangamma + 2* stdevgamma
end if
for m = 1 to binnumber do
     if gamma(m) ≥ 0.95* sill
   then range = H(m)
next
```

$$y\,\text{int} = gamma(2) - \left(\frac{gamma(3) - gamma(2)}{H(3) - H(2)}\right) * H(2)$$

```
if yint < 0 then nugget = 0
else nugget = yint
```

3. Build matrix C (using the covariance):

```
C1 = sill - nugget
for i = 1 to K do
   for j = 1 to K do
     if DK(i,j) ≠ 0 then C(i,j) = C1*e^(-3DK(i,j)/range)
      if DK(i,j) = 0 then C(i,j) = sill
     next
next
for i = 1 to K do
    C(i,K+1) = 1
next
for j = 1 to K do
    C(K+1,j) = 1
next
C(K+1,K+1) = 0
```

4. Invert the matrix C using Gauss-Jordan with full pivoting by LU decomposition.

5. Build the DCmat vector:

```
for i = 0 to xnum-1 do
    for j = 0 to ynum-1 do
```

```
            for m = 1 to K do
                        DP(m) =
```
$$\sqrt{(xcoordinate(i,j) - xk(m))^2 + (ycoordinate(i,j) - yk(m))^2}$$
```
                        if DP(m) ≠ 0 then DCmat(m) =
```
$$C1 * e^{\frac{-3DP(m)}{range}}$$
```
                        if DP(m) = 0 then DCmat(m) =
sill
           next
       DP(K+1) = 1
     next
next
```

6. Multiply the inverse of C by D to get the weights.

7. Calculate the normalized weights and the estimate:

```
sumw = 0
for m = 1 to K do
   sumw = w1(m) + sumw
          next
zvalue(i,j) = 0
for m = 1 to K do
```
$$weight(m) = {w1(m)}/{sumw}$$
$$zvalue(i,j) = zvalue + weight(m) * zk(m)$$
```
Next
```

2.5 Workflow Summary

During the extension of year 2, several large software tasks were undertaken:

- All interfaces have been changed from menu-drive into a work-flow style, which separates the defining functions into eight stages. Screenshots of major steps will be presented in a normal sequence at the end of this section.

1. **Start** - Project Manager allows users to create a new Fuzzy Expert System, modify a defined Fuzzy Expert System or delete an existing project. (Figs. 2.50 and 2.51).
2. **Characterize** - Default Data Manager allows users to input, modify, update and delete default data of variables (Figs 2.52–2.54 and 2.34–2.46)
3. **Variables** - Variable Manager allows users to define new variables, modify existing variables and delete variables (Fig. 2.55).
4. **Fuzzy Sets** - Fuzzy Sets Manager allows users to define, modify and delete fuzzy sets and membership shapes of Fuzzy Variables (Figs. 2.56 and 2.57)
5. **Interfaces** - Interface Manager allows users define, modify and delete the interfaces of Fuzzy Expert System in the interface style of the original FEE tool software (Figs. 2.58–2.60)
6. **Rules** - Rules Manager allows users to define, modify and delete the rules related to defined variables and flags (Figs. 2.61 and 2.62).
7. **Parameters** - Weights Manager allows users to adjust the weight value of each variable for inference engine of Fuzzy Expert System (Fig. 2.63).

- Each stage is divided into a few simple steps that users can easily understand and follow. "Previous" and "Next" buttons on most steps allow users to navigate to previous step or navigate to a later process from the current step. Each step contains a title, a short instruction and one/more components (Radio buttons, text fields, combo box, etc.) which allow users to input, view, modify data or select options, or data.

- The entire software package has been re-implemented in JAVA 1.60 with a noted increase in software performance.

- CFS source codes have grown to 1,545,588 bytes (1.5MB) with a total of 51,165 lines since the end of the first project year (1,123,492 bytes with a total of 35,992 lines). This corresponds to a 40% growth in software, primarily in wizards and interfaces.

Some software issues remain to be determined through the use of beta testers. A summary of these issues follows:

- Because the number of most data items is not fixed in the CFS, it is hard to decide how to determine when a process can be checked as complete on the sidebar with regard to present project state. For example, the number of variables, rules, questions, and fuzzy sets are all variable. We are considering a new way to display the state of the system to the user, or the answer may become obvious once users are testing the system under a broader set of circumstances.

- Due to interface improvements with JAVA 1.60, which allows users to have multiple open windows or stages, some data needs to be simultaneously shared by more than one application. This requires real time data update (communication) among processes (stages) and may require that the data management software needs to be improved.

Generally speaking, the CFS is in a stage of development which requires beta user input for improving, integrating and debugging software and to accomplish the desired level of wizard functionality and user-friendliness.

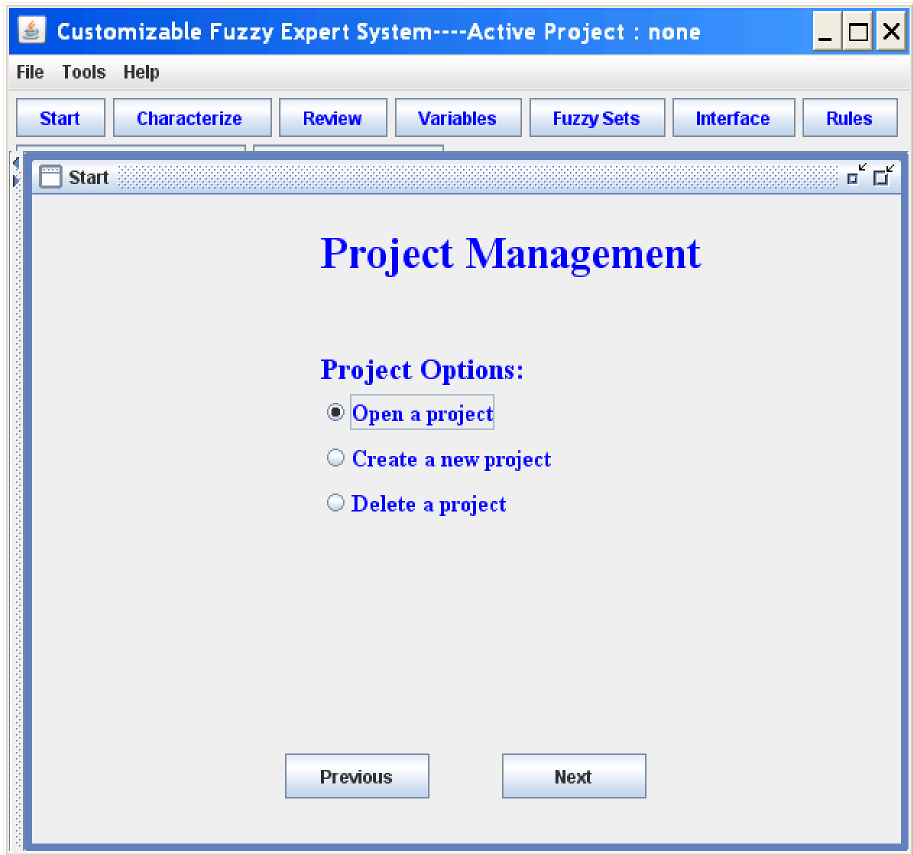


Fig. 2.50. Application screen with Project Management application running.

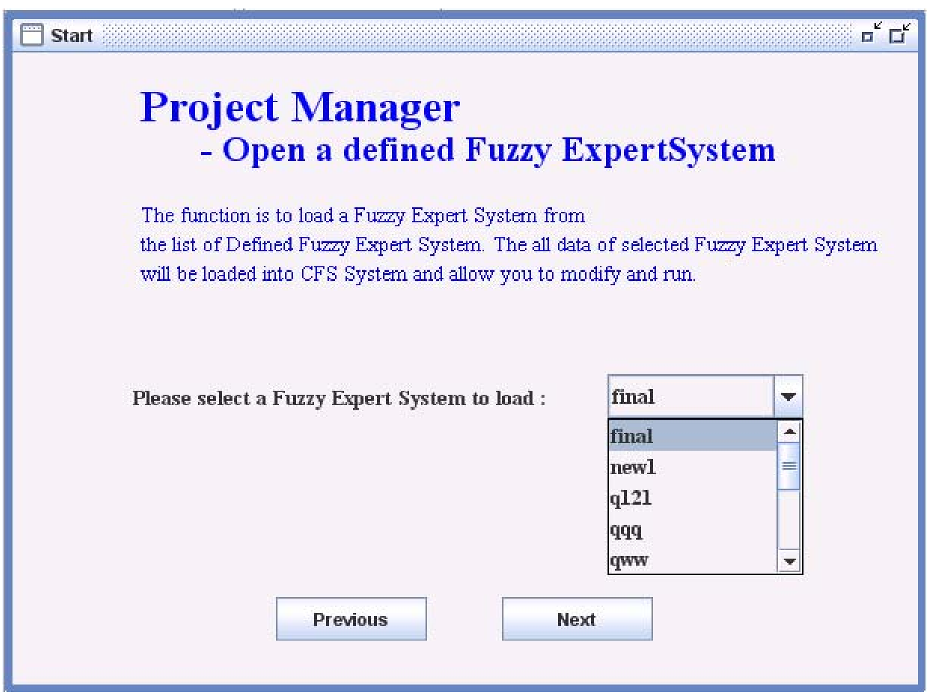


Fig. 2.51. Sample screen for loading an existing project.

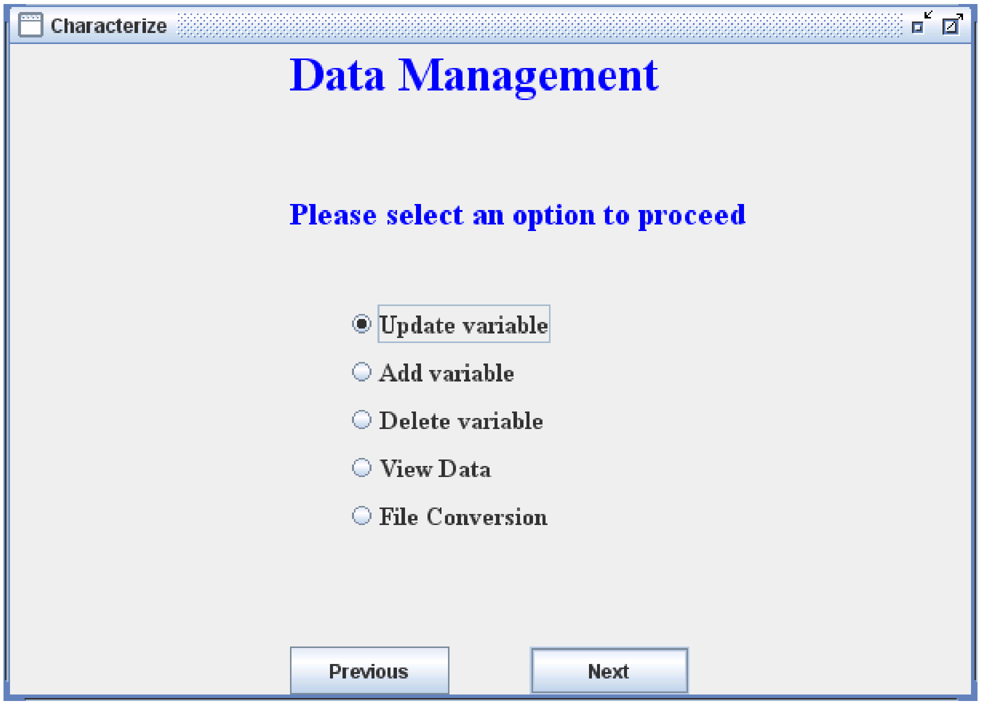


Fig. 2.52. Data Management application options.

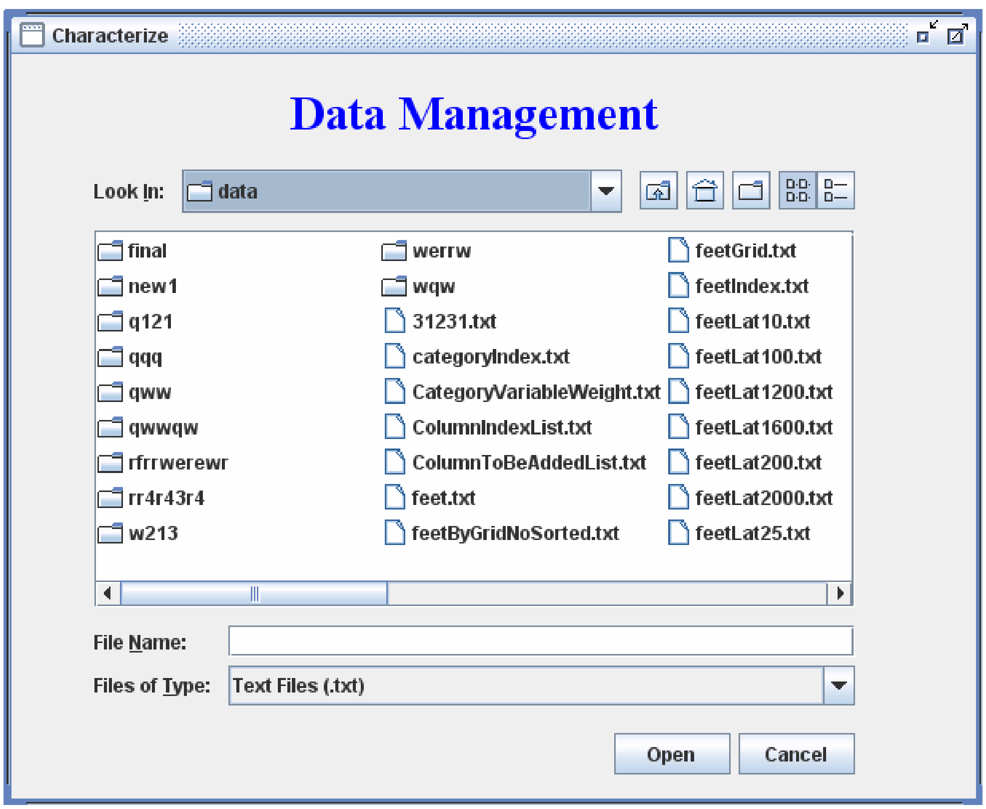


Fig. 2.53. Select file screen.

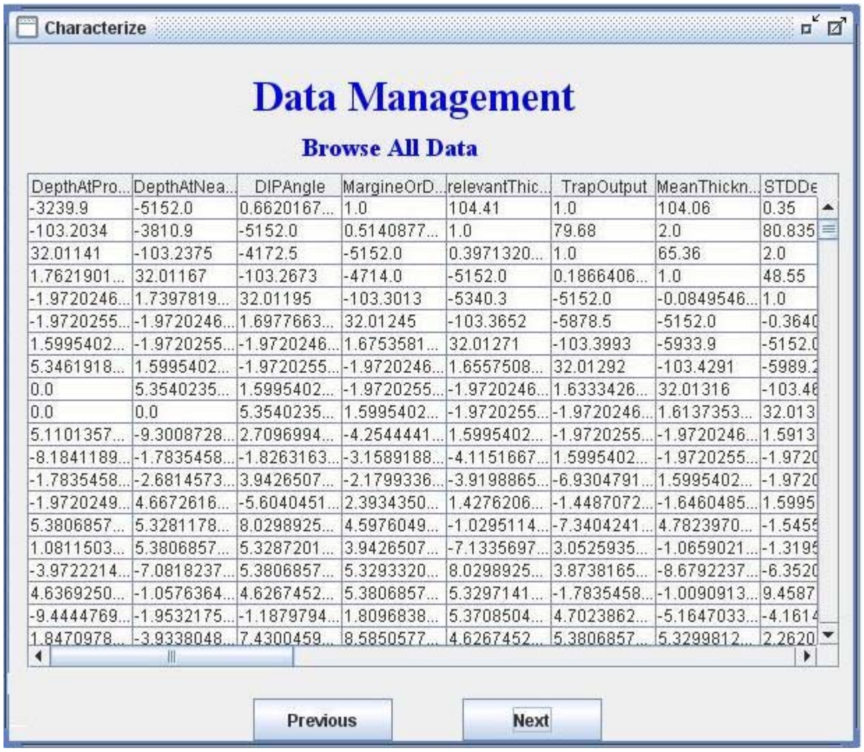


Fig. 2.54. Browse data application.

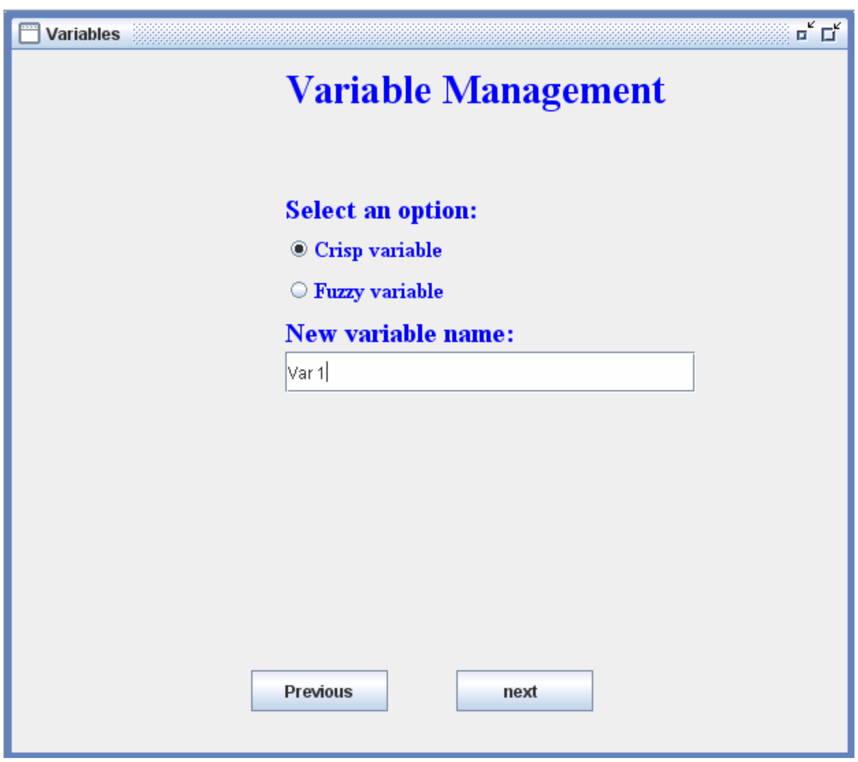


Fig. 2.55. Application screen for managing fuzzy variables.

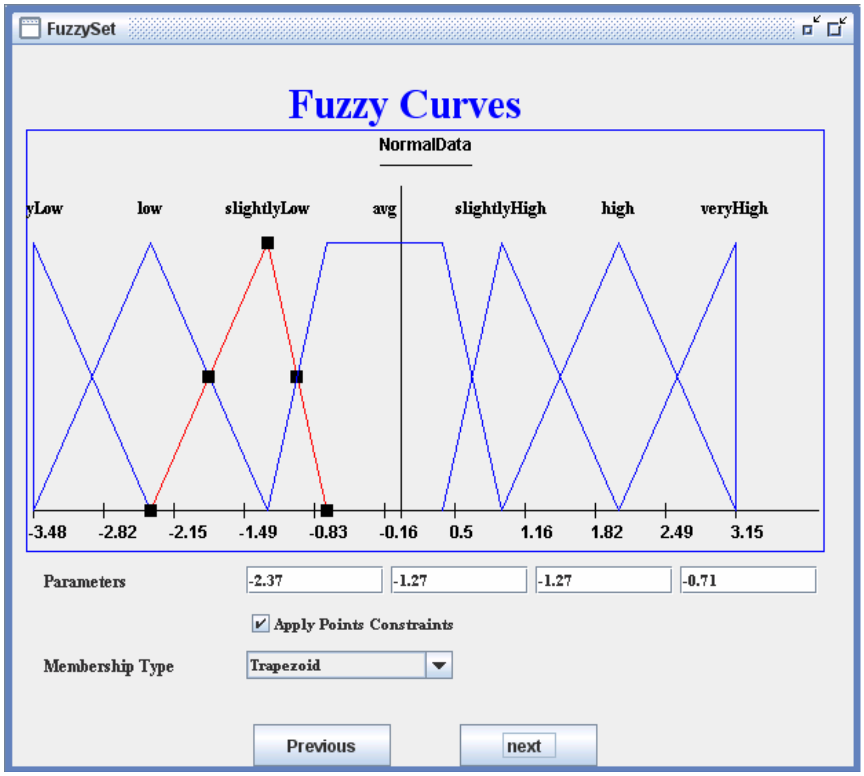


Fig. 2.56. Displayed fuzzy curves for a defined variable.

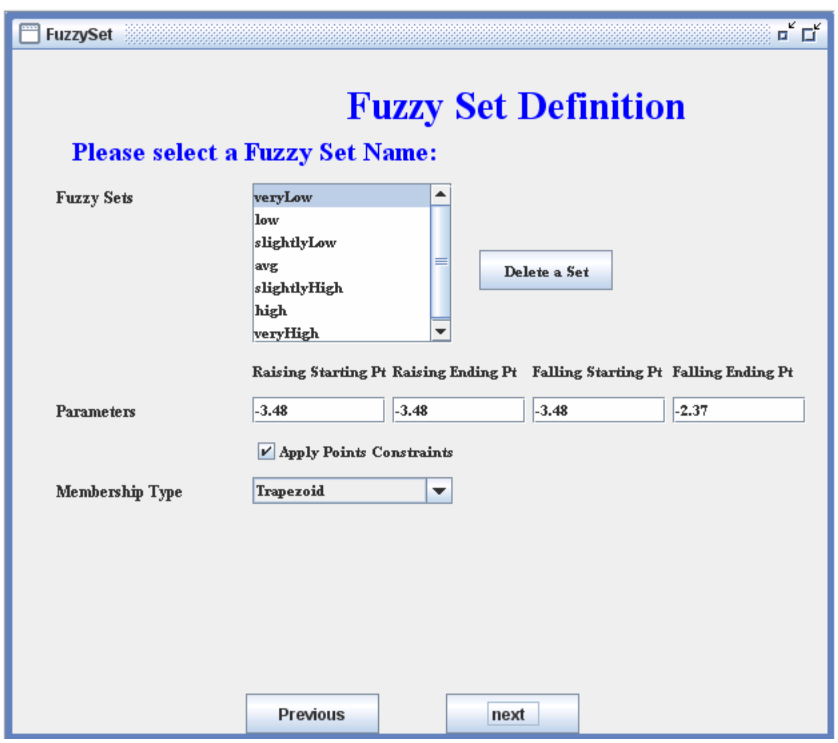


Fig. 2.57. Set definition screen for fuzzy variables.

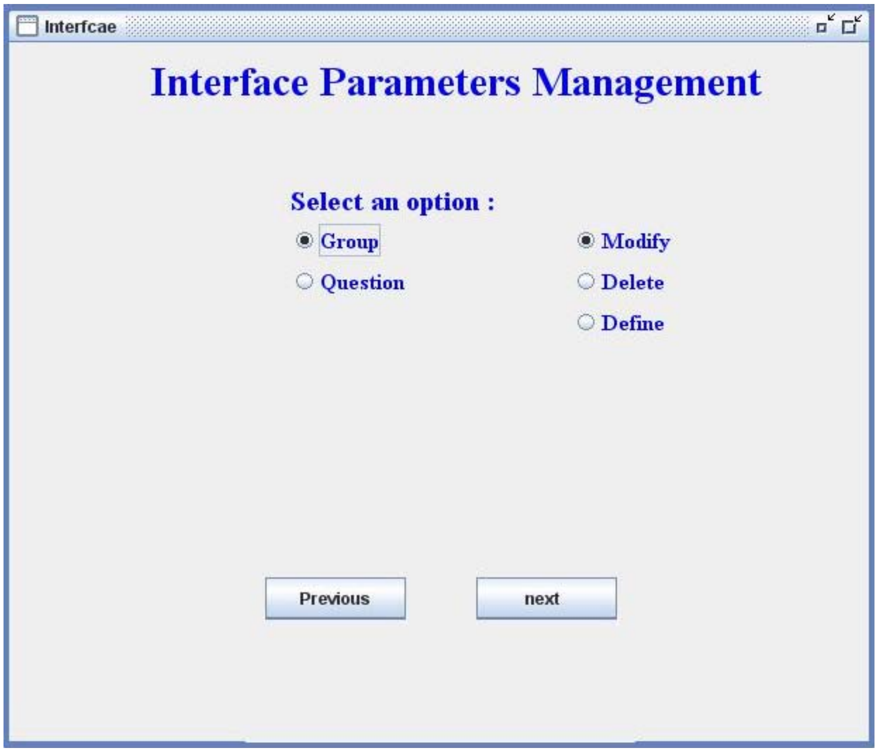


Fig.2.58. Interface management screen.

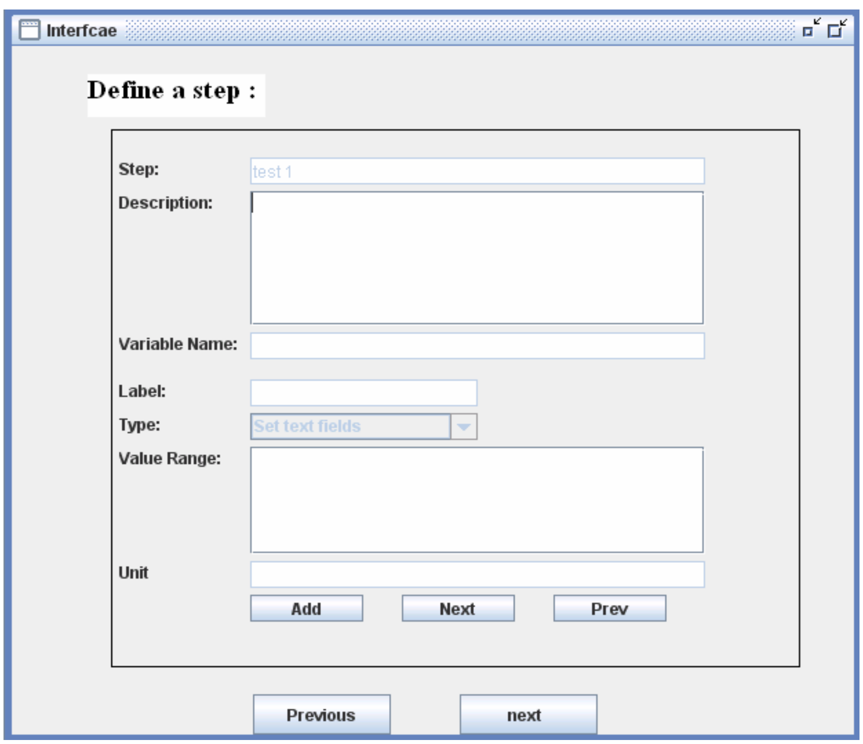


Fig. 2.59. In this application, text of questions can be entered.

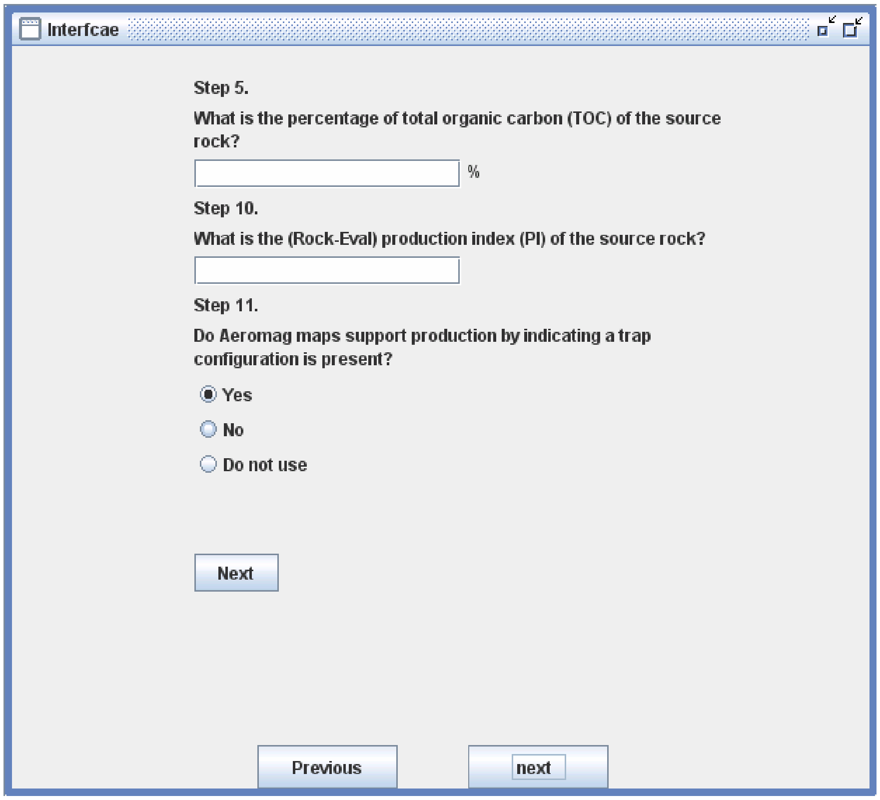
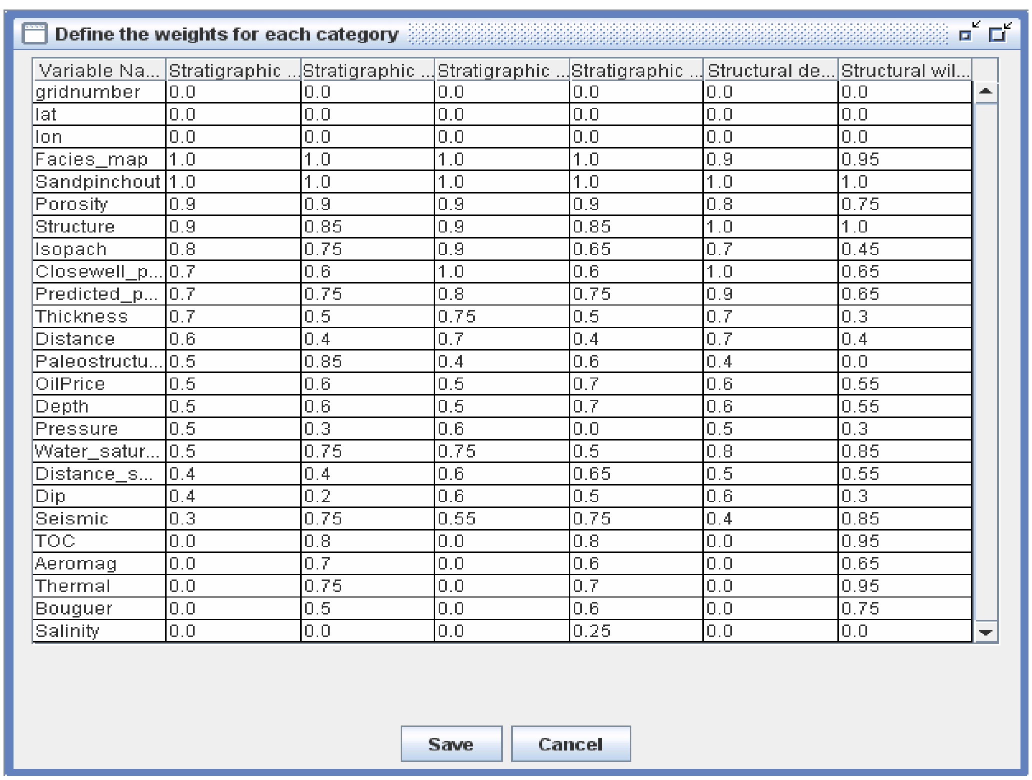


Fig. 2.60. Sample output for entered questions.

Fig. 2.61. Inference parameter setup application introduction screen.

Fig. 2.62. Boolean logic can be used to define inference parameters.



Variable Na...	Stratigraphic ...	Stratigraphic ...	Stratigraphic ...	Stratigraphic ...	Structural de...	Structural wil...
gridnumber	0.0	0.0	0.0	0.0	0.0	0.0
lat	0.0	0.0	0.0	0.0	0.0	0.0
lon	0.0	0.0	0.0	0.0	0.0	0.0
Facies_map	1.0	1.0	1.0	1.0	0.9	0.95
Sandpinchout	1.0	1.0	1.0	1.0	1.0	1.0
Porosity	0.9	0.9	0.9	0.9	0.8	0.75
Structure	0.9	0.85	0.9	0.85	1.0	1.0
Isopach	0.8	0.75	0.9	0.65	0.7	0.45
Closewell_p...	0.7	0.6	1.0	0.6	1.0	0.65
Predicted_p...	0.7	0.75	0.8	0.75	0.9	0.65
Thickness	0.7	0.5	0.75	0.5	0.7	0.3
Distance	0.6	0.4	0.7	0.4	0.7	0.4
Paleostructu...	0.5	0.85	0.4	0.6	0.4	0.0
OilPrice	0.5	0.6	0.5	0.7	0.6	0.55
Depth	0.5	0.6	0.5	0.7	0.6	0.55
Pressure	0.5	0.3	0.6	0.0	0.5	0.3
Water_satur...	0.5	0.75	0.75	0.5	0.8	0.85
Distance_s...	0.4	0.4	0.6	0.65	0.5	0.55
Dip	0.4	0.2	0.6	0.5	0.6	0.3
Seismic	0.3	0.75	0.55	0.75	0.4	0.85
TOC	0.0	0.8	0.0	0.8	0.0	0.95
Aeromag	0.0	0.7	0.0	0.6	0.0	0.65
Thermal	0.0	0.75	0.0	0.7	0.0	0.95
Bouguer	0.0	0.5	0.0	0.6	0.0	0.75
Salinity	0.0	0.0	0.0	0.25	0.0	0.0

Fig. 2.63. Defined weights of variables for a sample projects.

3. Task 3: Geologic Data Acquisition and Analysis

First Project Year

From January 2005 through December 2005, geologic data acquisition and analysis commenced and saw significant progress on the Upper Pennsylvanian and Lower Permian carbonate reservoirs (generally referred to as ***Permo-Pennsylvanian*** reservoirs but also known as ***Bough*** reservoirs) within the first project area in the Permian Basin of southeastern New Mexico (Figs. 3.1-3.3). These 58 Permo-Pennsylvanian reservoirs that are at least partially present within the Bough project area have produced a combined total of 264 million bbls oil (MMBO; Table 3.1). The Bough has been subdivided informally by industry geologists into four widely recognized members (descending; Bough A member, Bough B member, Bough C member, Bough D member). The Bough zones have long been recognized as straddling the boundary between the Upper Pennsylvanian and the Lower Permian [Cys, 1986] with Bough A, B, and C placed within the lowermost part of the Permian and Bough D placed in the uppermost part of the Pennsylvanian. The most recent work [Wahlman, 2001] raises the boundary between the Permian and the Pennsylvanian and would apparently place the entire Bough section in the uppermost Pennsylvanian. The Bough reservoirs are productive from phylloid algal mounds and associated flanking grainstones [Cys and Mazzullo, 1985; Malek-Aslani, 1985; Cys, 1986; Broadhead, 1999a, 1999b; Wahlman, 2001]. The reservoirs from the shelf-margin project area are productive primarily from Canyon and Cisco strata within the Upper Pennsylvanian and therefore are mostly somewhat older than the reservoirs within the intrashelf project area. However, they are also productive from phylloid algal mounds and associated flanking deposits (see Cox et al., 1998) and therefore should have similar reservoir characteristics.

Our work for the first year indicated that the Bough C member (Figs. 3.1, 3.4) dominates production within the Bough intrashelf project area. During the first project year (calendar year 2005), basic geologic data pertaining to structure, paleostructure, and the stratigraphic environments relevant to oil and natural gas production in the intrashelf project area were obtained from well records and by analyzing and correlating electric logs from 300 wells drilled within the 1300 mi^2 project area. It is estimated that approximately one-half of the geologic data required for the project were obtained during this first year of the project.

Table 3.1. Permo-Pennsylvanian Carbonate Reservoirs Productive within the Bough Intrashelf Project Area. This table includes data from Years 1 and 2. (See Fig. 3.5 for Locations of Reservoirs)

Reservoir name	Productive unit	2003 oil production (bbls oil)	Cumulative oil production 2003 (million bbls)
Allison	Upper Pennsylvanian	30645	23.92
Alston Ranch	Upper Pennsylvanian	0	0.14
Anderson Ranch North	Wolfcamp	27785	6.74
Austin	Permo Penn	101	0.06
Austin Northwest	Permo Penn	0	0.61
Austin Southwest	Wolfcamp	0	0.03
Bagley	Pennsylvanian	998	4.34
Bagley East	Upper Pennsylvanian	2195	0.25
Bagley East	Wolfcamp	0	0.02
Bagley North	Permo Penn	138830	53.40
Bar-U	Upper Pennsylvanian	25667	1.46
Baum	Upper Pennsylvanian	21159	15.30
Baum North	Wolfcamp	1221	0.03
Baum South	Wolfcamp	98	0.04
Bluitt	Wolfcamp	5577	0.58
Bough	Permo Penn	0	6.33
Bronco Southwest	Wolfcamp	11203	0.24
Caprock North	Wolfcamp	1775	0.09
Caprock	Wolfcamp	0	0.00
Caprock East	Wolfcamp	5213	0.43
Caudill	Permo Upper Penn	9198	2.01
Caudill Northeast	Wolfcamp	0	0.32
Cerca	Upper Pennsylvanian	0	1.98
Cindy	Wolfcamp	0	0.02
Crossroads	Upper Pennsylvanian	0	2.17
Denton	Wolfcamp	219118	42.44
Denton East	Wolfcamp	0	0.02
Echols	Wolfcamp	0	0.01
Eight Mile Draw	Permo Upper Penn	0	0.09
Flying M South	Bough	0	1.21
Flying M	Pennsylvanian	4498	0.07
Feather East	Upper Pennsylvanian	1390	0.06
Four lakes	Upper Pennsylvanian	8520	2.77
Gladiola	Wolfcamp	13565	4.19
Gladiola South	Wolfcamp	1284	0.17
High Plains	Permo Upper Penn	7988	1.06
Hightower East	Upper Pennsylvanian	7824	1.08
Hightower	Permo Penn	4109	0.71
Hightower	Wolfcamp	0	0.00
Inbe	Permo Upper Penn	8730	16.47
Jenkins	Cisco	0	2.10
King	Wolfcamp	57482	1.50
King	Pennsylvanian	0	0.09
King West	Pennsylvanian	0	0.01
Lane	Wolfcamp	0	1.03

Llano	Upper Pennsylvanian	0	0.00
Reservoir name	**Productive unit**	**2003 oil production (bbls oil)**	**Cumulative oil production 2003 (million bbls)**
McDonald	Upper Pennsylvanian	2091	0.16
Mescalero North	Upper Pennsylvanian		0.00
Mescalero North	Cisco	50446	0.61
Mescalero	Permo-Pennsylvanian	2115	0.97
Mescalero West	Pennsylvanian	0	0.00
Mescalero Northeast	Cisco	657	0.02
Mescalero North	Wolfcamp	0	0.06
Milnesand	Pennsylvanian	0	1.00
Milnesand East	Pennsylvanian	0	0.00
Milnesand West	Pennsylvanian	21799	0.36
Moore	Permo Penn	270	0.23
Morton	Wolfcamp	6784	2.63
Morton East	Wolfcamp	16858	1.84
Morton North	Permo Upper Penn	0	0.86
Nonombre	Upper Pennsylvanian	0	1.08
Nonombre North	Upper Pennsylvanian	613	0.04
Pollock	Wolfcamp	0	0.23
Prairie South	Cisco	0	2.91
Prairie South	Wolfcamp	0	0.04
Ranger Lake	Upper Pennsylvanian	7396	5.11
Ranger Lake	Bough	2583	0.27
Ranger Lake East	Cisco	0	0.00
Saunders	Permo-Upper Penn	71081	39.20
Saunders East	Permo Penn	4932	2.73
Saunders South	Permo Upper Penn	2115	0.29
SRR	Upper Pennsylvanian	0	0.04
Tatum	Upper Pennsylvanian		0.20
Tatum	Wolfcamp	0	0.68
Tobac	Upper Pennsylvanian	11501	9.27
Todd	Wolfcamp	24599	1.19
Tres Papalotes	Upper Pennsylvanian	43773	2.11
Tres Papalotes West	Upper Pennsylvanian	0	1.24
Tulk	Pennsylvanian	12624	1.85
Tulk	Wolfcamp	16957	2.48
Tulk North	Wolfcamp	0	0.02
Tulk Southwest	Wolfcamp	2957	0.05
Vada	Upper Pennsylvanian	34252	53.43

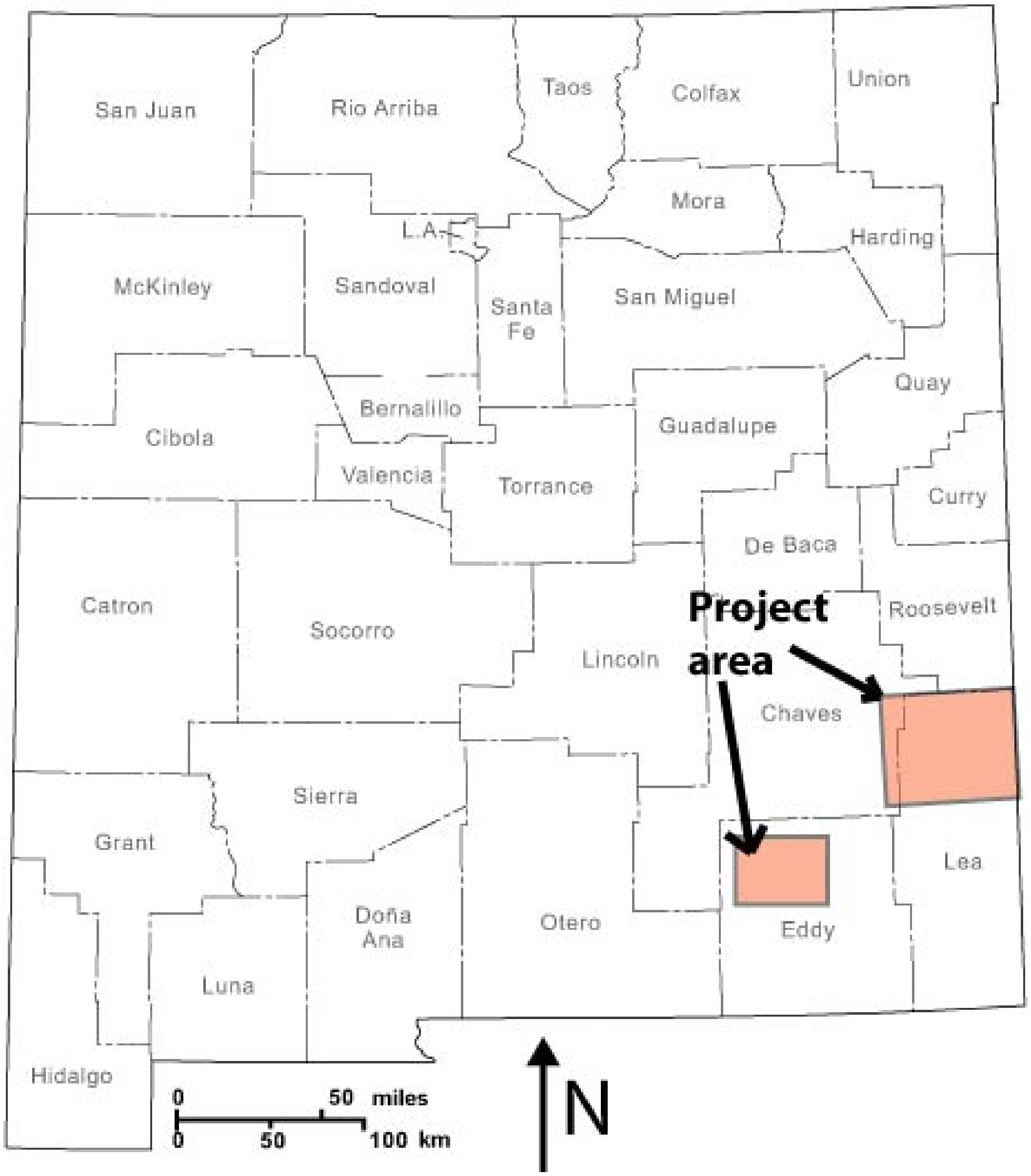


Fig. 3.1. Location of project areas in New Mexico: the Bough intershelf area and the Dagger Draw area that was added in the second year of the project.

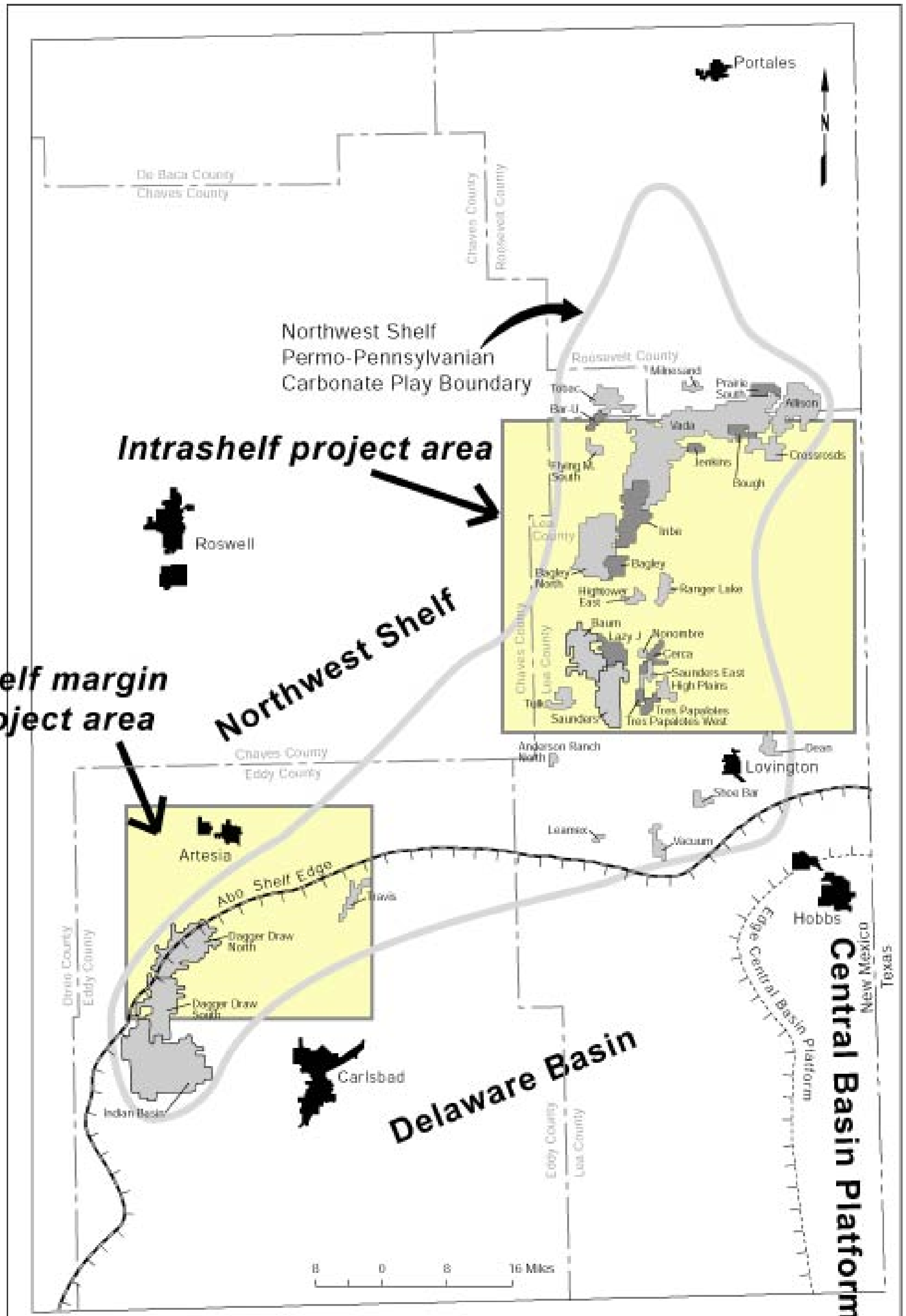


Fig. 3.2. Location of project areas in southeastern New Mexico in relationship to boundaries of the Permo-Pennsylvanian carbonate reservoir oil play and major tectonic elements. Shown in gray are oil reservoirs that have produced more than 1 million bbls oil from Upper Pennsylvanian and Lower Permian carbonate reservoirs. Modified from Broadhead and others (2004).

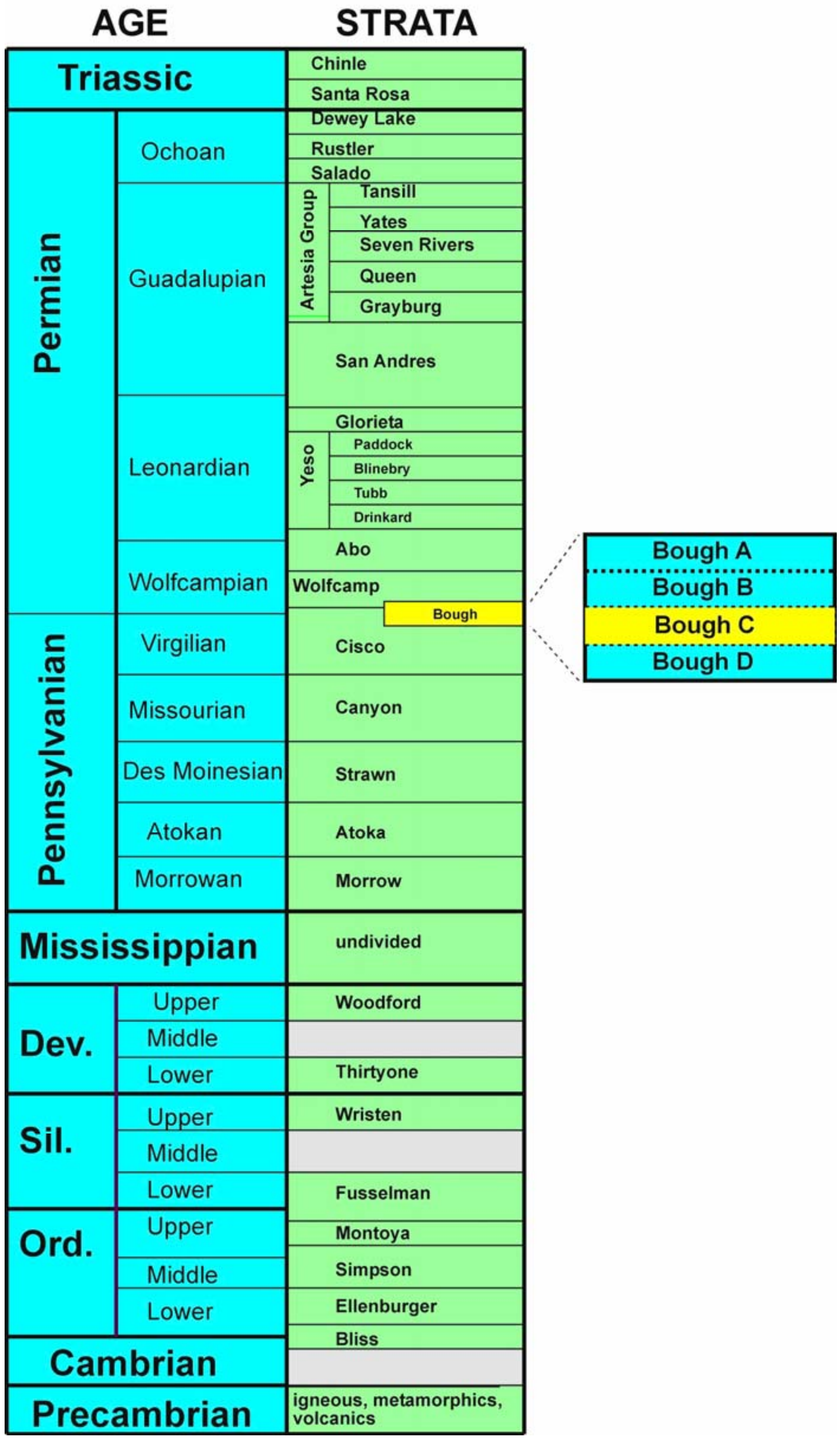


Fig. 3.3. Stratigraphic chart of the Northwest Shelf of the Permian Basin emphasizing the productive Bough carbonate reservoirs. The Bough C member (highlighted in yellow) is the major productive Bough member within the intrashelf project area. Canyon strata contain the major productive reservoirs within the shelf-margin project area with secondary production provided by reservoirs in Cisco strata.

Project Tasks – Geologic Data and Acquisition

The following tasks were enjoined during the first project year.

1. ***Production and stratigraphic data compiled:*** on Permo-Penn carbonate reservoirs within the project area.
2. ***Stratigraphic data acquisition in wells:*** Correlated productive Permo-Penn carbonate zones in 224 wells throughout the project area.
3. ***Stratigraphic data mapping and analysis*****:** Made preliminary isopach maps of productive Permo-Penn carbonate reservoir zones in the project area.
4. ***Structural data acquisition*****:** Correlated the stratigraphic tops of the Abo Formation (Lower Permian) and the Mississippian System in 300 wells within the project area.
5. ***Structural data mapping and analysis*****:** Constructed structure contour maps of the upper surface of the Abo Formation and the Mississippian System within the project area and related structure to production from Permo-Penn carbonate reservoirs.
6. ***Paleostructural mapping and analysis*****:** Structural data on multiple formations were used to create a paleostructure map of positive tectonic elements that were formed concurrently with deposition of Bough reservoirs. Positive paleostructural elements were related to production from Permo-Penn carbonate reservoirs.

Each of these tasks is discussed more fully below and maps produced as a result of tasks are presented.

1. ***Compiled production and stratigraphic data on Permo-Penn (Bough) carbonate reservoirs within the project area.*** Reservoir-wide annual production data and stratigraphic data were compiled for the 58 designated oil reservoirs that produce from Permo-Penn carbonate reservoirs within the boundaries of the project area (Table 3.1). Compiled data includes cumulative oil production data for each reservoir. A database was also produced for 224 wells within the project area that

includes production data for each well, depth of perforated productive reservoirs, and a summary of pertinent information for nonproductive wells.

2. ***Stratigraphic data acquisition in wells:*** Productive Permo-Penn carbonate zones were correlated in 224 wells throughout the project area. Where penetrated by wells, the tops of the Bough A, Bough B, Bough C and Bough D members (Fig. 3.4) were correlated with gamma ray, resistivity, and other borehole logs. Inasmuch as the traps that form oil reservoirs in Bough strata are largely stratigraphic [see Broadhead, 1999; Cys, 1986; Cys and Mazzullo, 1985; Malek-Aslani, 1985; Wahlman, 2001], the acquisition of stratigraphic data pertinent to oil entrapment is considered a key ingredient of this project. In order to ensure adequate, consistent and correct correlations, 14 reference cross sections utilizing 126 wells were first produced throughout the project area (Fig. 3.5). The wells were rigorously correlated into closed loops to eliminate correlation inconsistencies and errors. The latitude and longitude of the well locations were calculated using a digital land grid and *Geographix* software (*Geographix* is a registered trademark of Landmark Graphics, Inc.) that uses the digital land grid to convert surveyed footage measurements of wells from section boundaries into latitude and longitude. Well names, locations and depths to the tops of the Bough A, Bough B, Bough C and Bough D members were entered into an Excel database. Once the cross sections were completed and reviewed for errors, they were then used to correlate the tops of the Bough A, Bough B, Bough C and Bough D members in 98 other wells that filled in data gaps in sections without cross sections. The locations of these other wells in terms of latitude and longitude had not yet been calculated by the first year, so these additional wells do not appear in Fig. 3.5 or in any of the isopach maps of the Bough members (Figs. 3.5–3.8); these well locations were calculated early in 2006, in the second project year. Maps made with data from the additional wells revealed variations in stratigraphy that are responsible for the localization of hydrocarbon traps (Figs. 3.x-3.y). In total, the tops of the Bough A, Bough B, Bough C and Bough D were correlated in 224 wells during 2005.

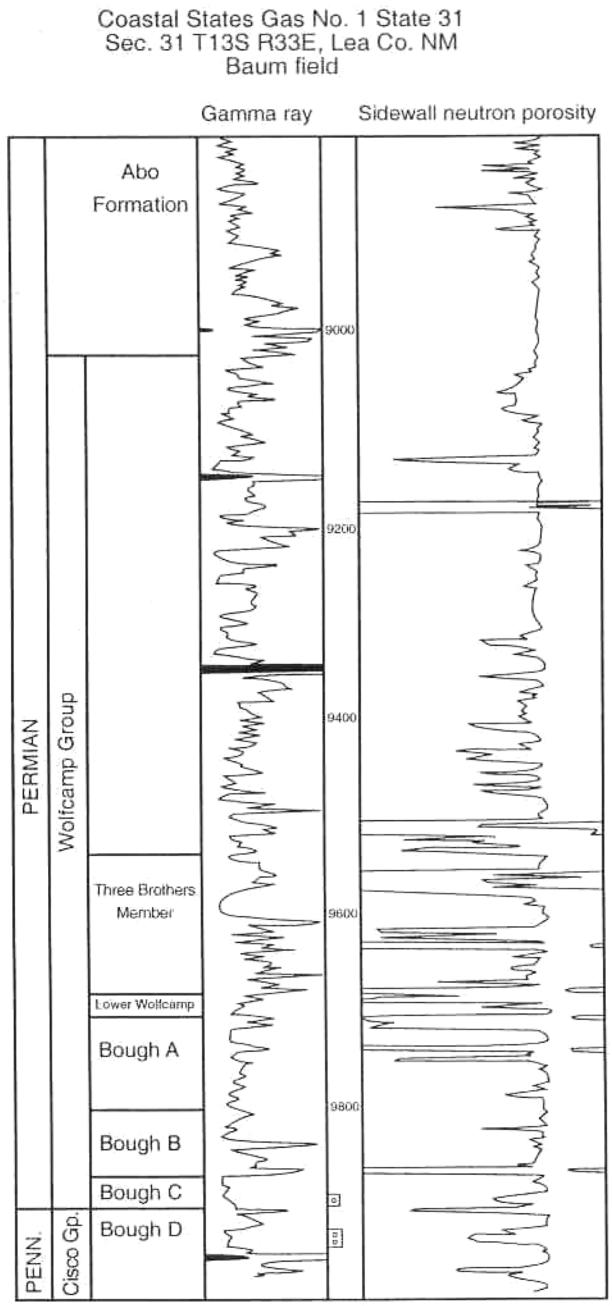


Fig. 3.4. Typical well log through the Bough members within the project area. From Broadhead (1999).

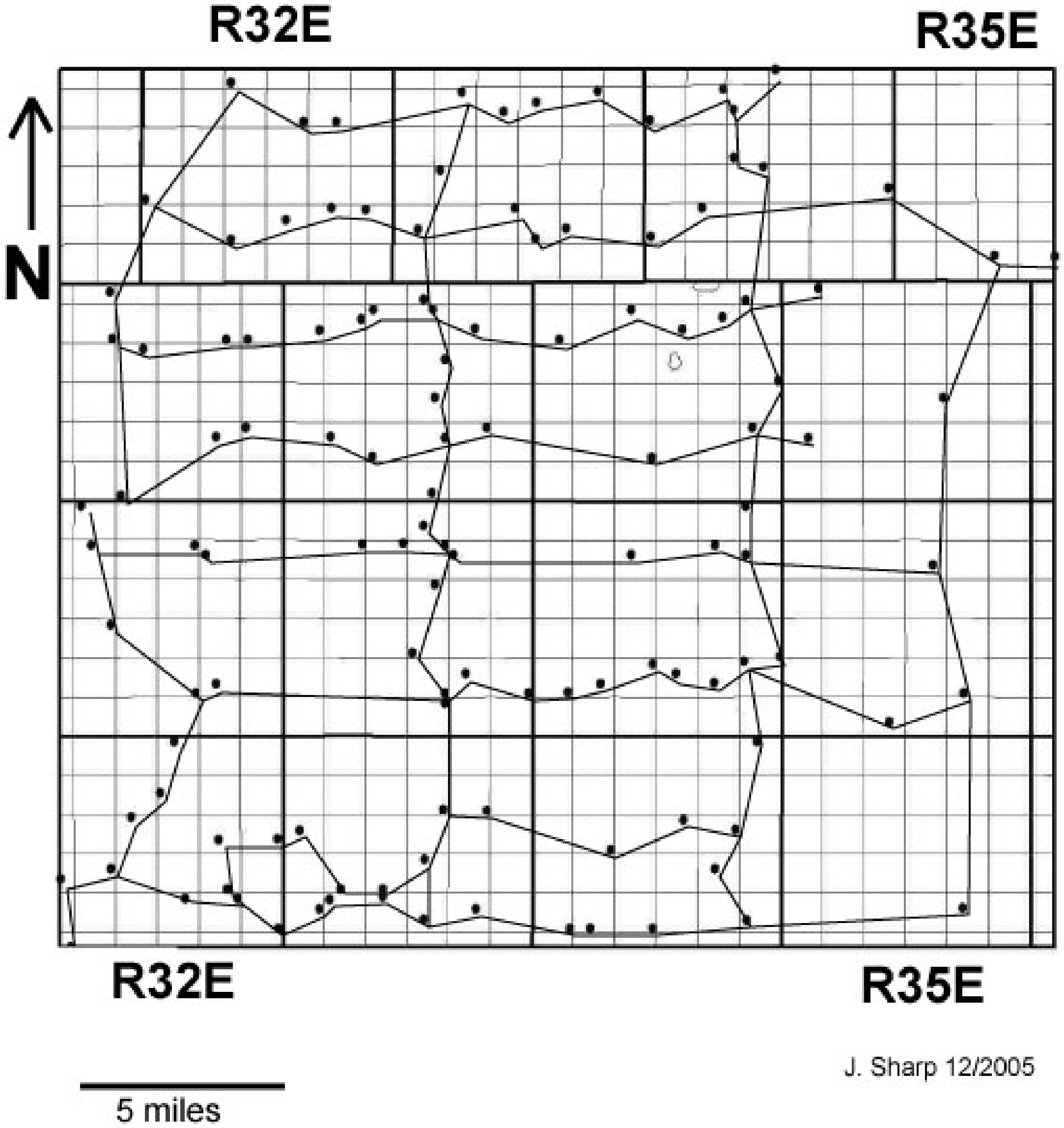


Fig. 3.5. Locations of cross sections used in correlation of Bough members.

3. ***Stratigraphic data mapping and analysis*****:** Preliminary digital isopach maps were made of the Bough A, Bough B and Bough C members using the cross section wells (Figs. 3.6–3.8). These maps were produced using Surfer 8, a modern and sophisticated contouring program (*Surfer 8* is a registered trademark of Golden Software, Inc.). Final maps were produced in the second year of the project, after

the latitude and longitude locations of additional infill wells were calculated and entered into the database and the additional wells were correlated.

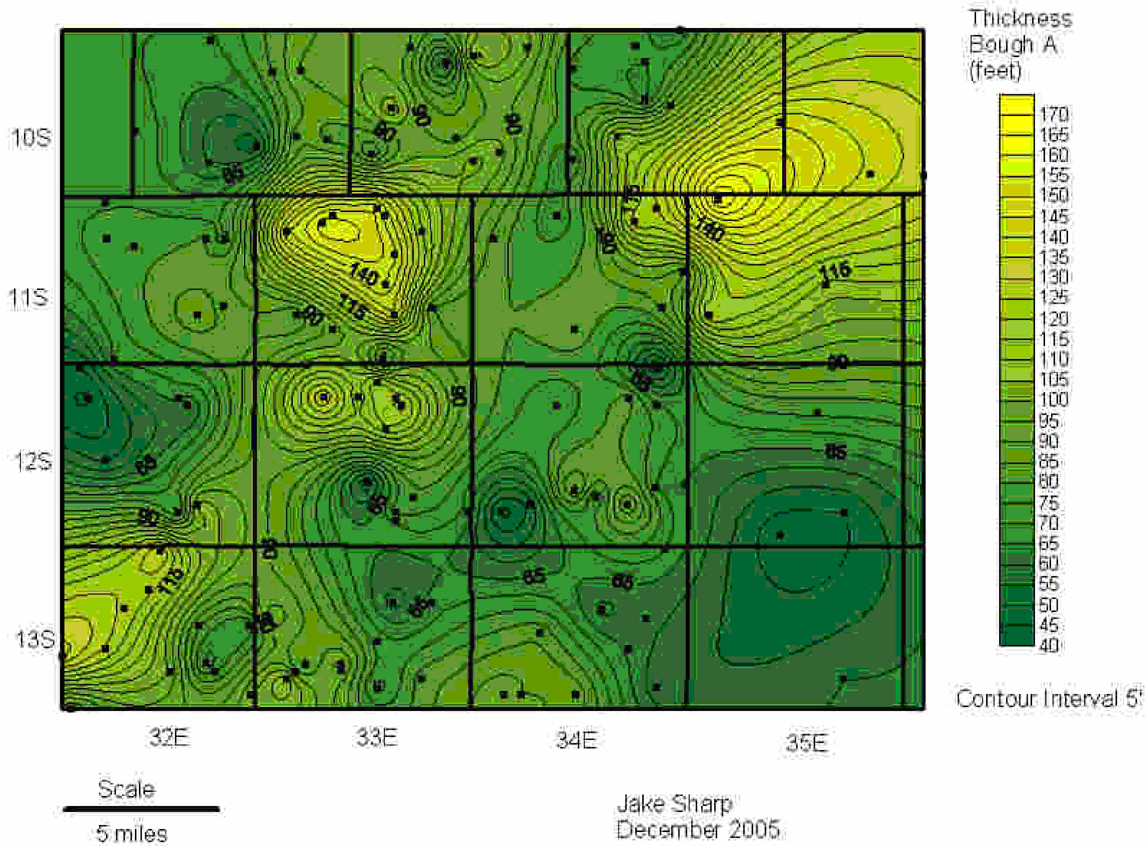


Fig. 3.6. Isopach map of Bough A member with first year project data (without additional wells).

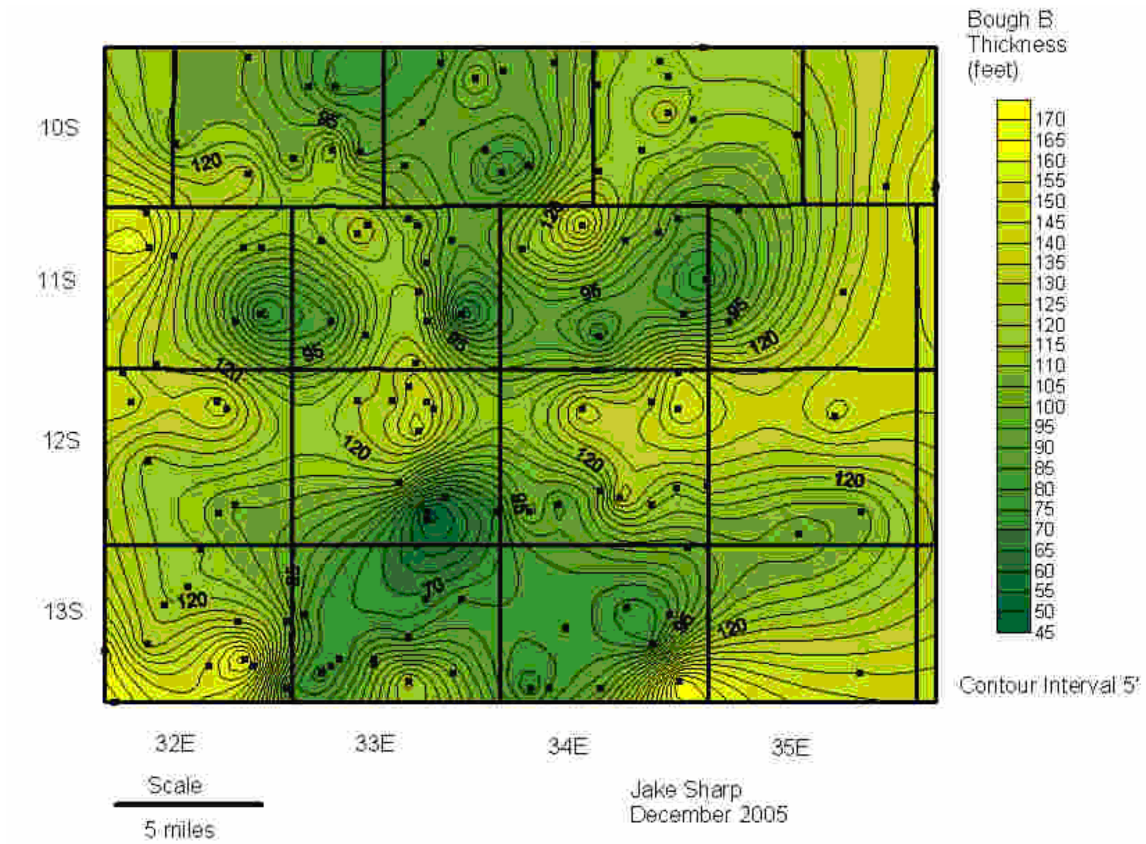


Fig. 3.7. Isopach map of Bough B member with first year project data.

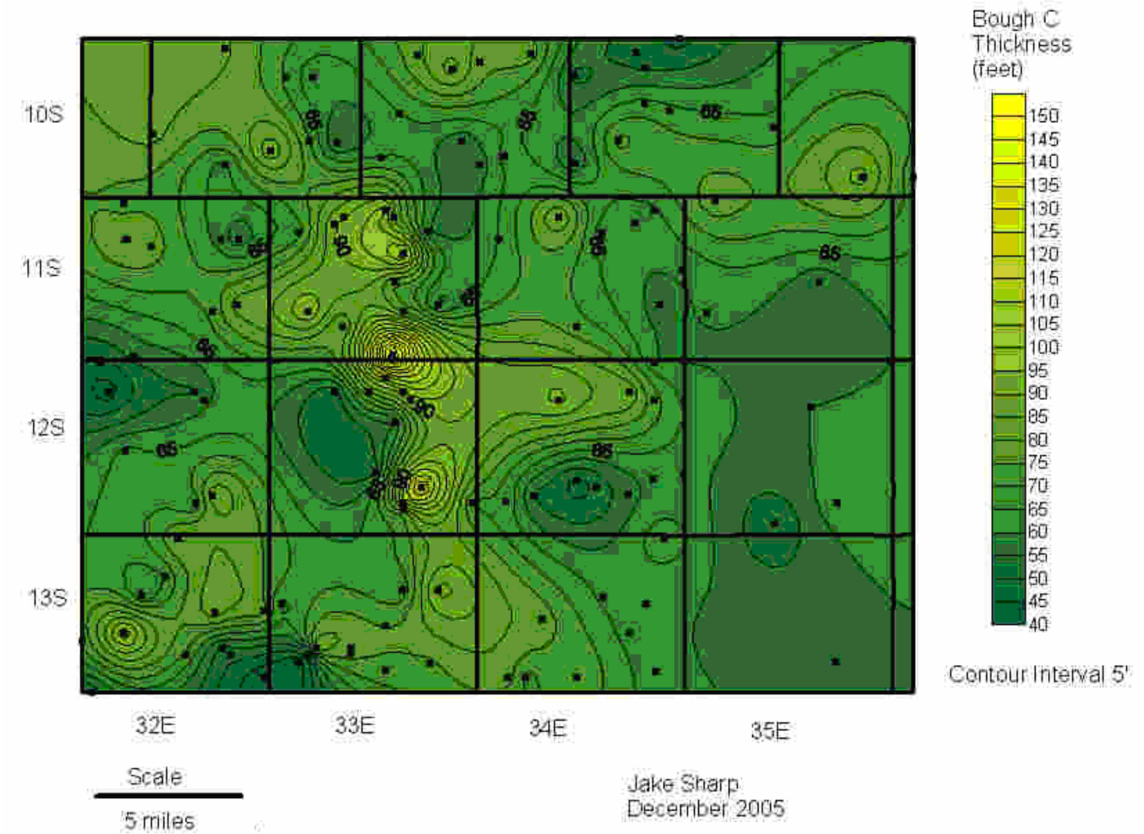


Fig. 3.8. Isopach map of Bough C member with first year project data.

4. ***Structural data acquisition*:** In addition to depths to the top of the Bough members, depths to the top of the Abo Formation (Lower Permian) and the Mississippian System (Fig. 3.3) were correlated in 300 wells using gamma-ray logs, electric logs, and sample logs (Fig. 3.9).

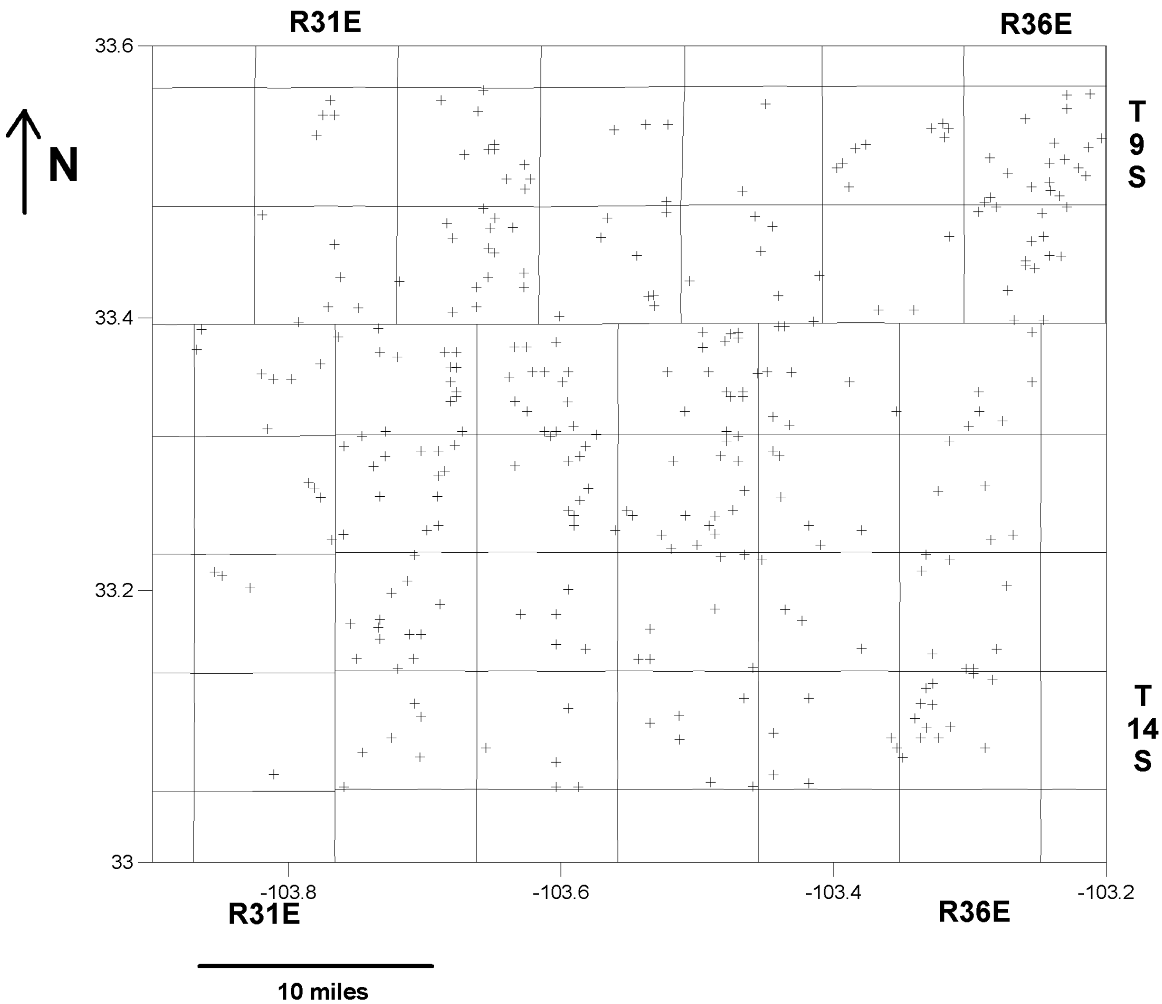


Fig. 3.9. Locations of wells for which the tops of the Abo Formation (Lower Permian) and the Mississippian System were correlated.

5. ***Structural data mapping and analysis*****:** Digital structure contour maps were prepared with Surfer 8 for the upper surface of the Bough C member (Fig. 3.10), the Abo Formation (Fig. 3.11), and the Mississippian System (Fig. 3.12). The boundaries of oil pools productive from the Permo-Penn carbonate reservoirs were superimposed upon the structure maps (Figs. 3.13–3.14). No exact correlations between the Abo structure map and the locations of oil reservoirs are apparent. However, there is a general correlation between the locations of oil reservoirs and closed contours delimiting positive areas on the Mississippian structure map.

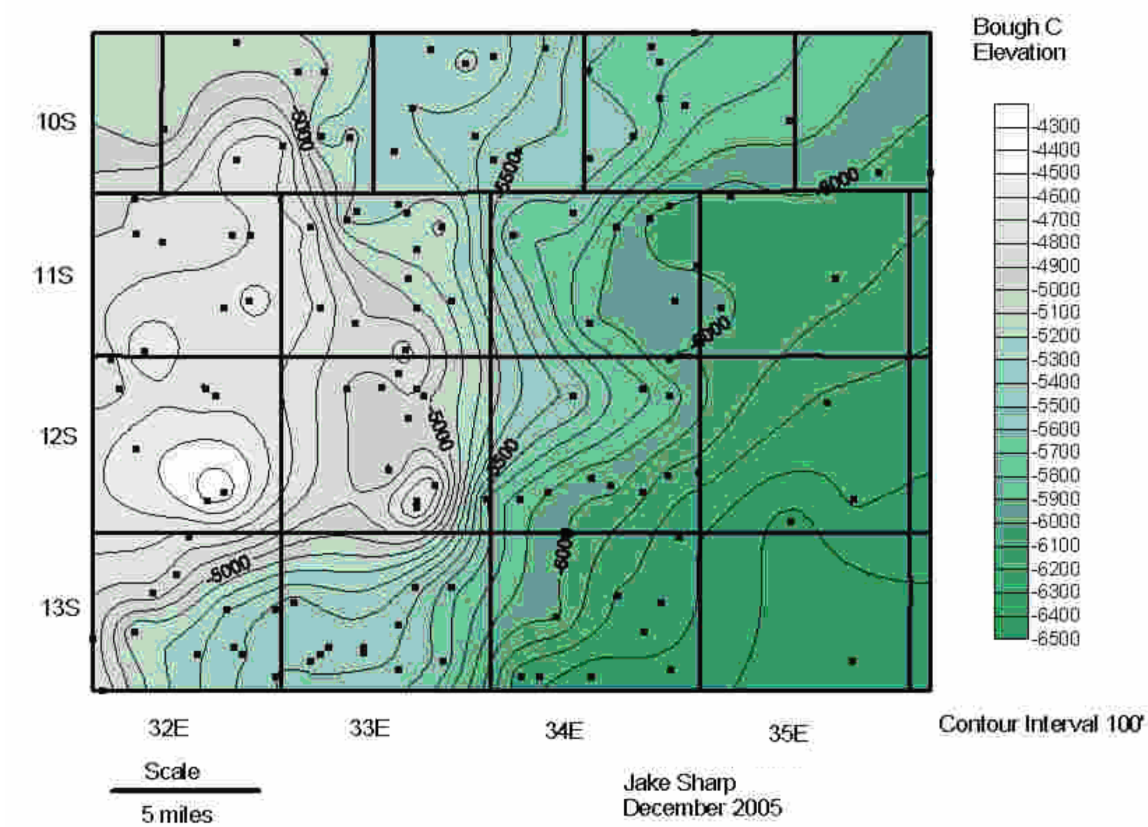


Fig. 3.10. Structure contour map on the upper surface of the Bough C member.

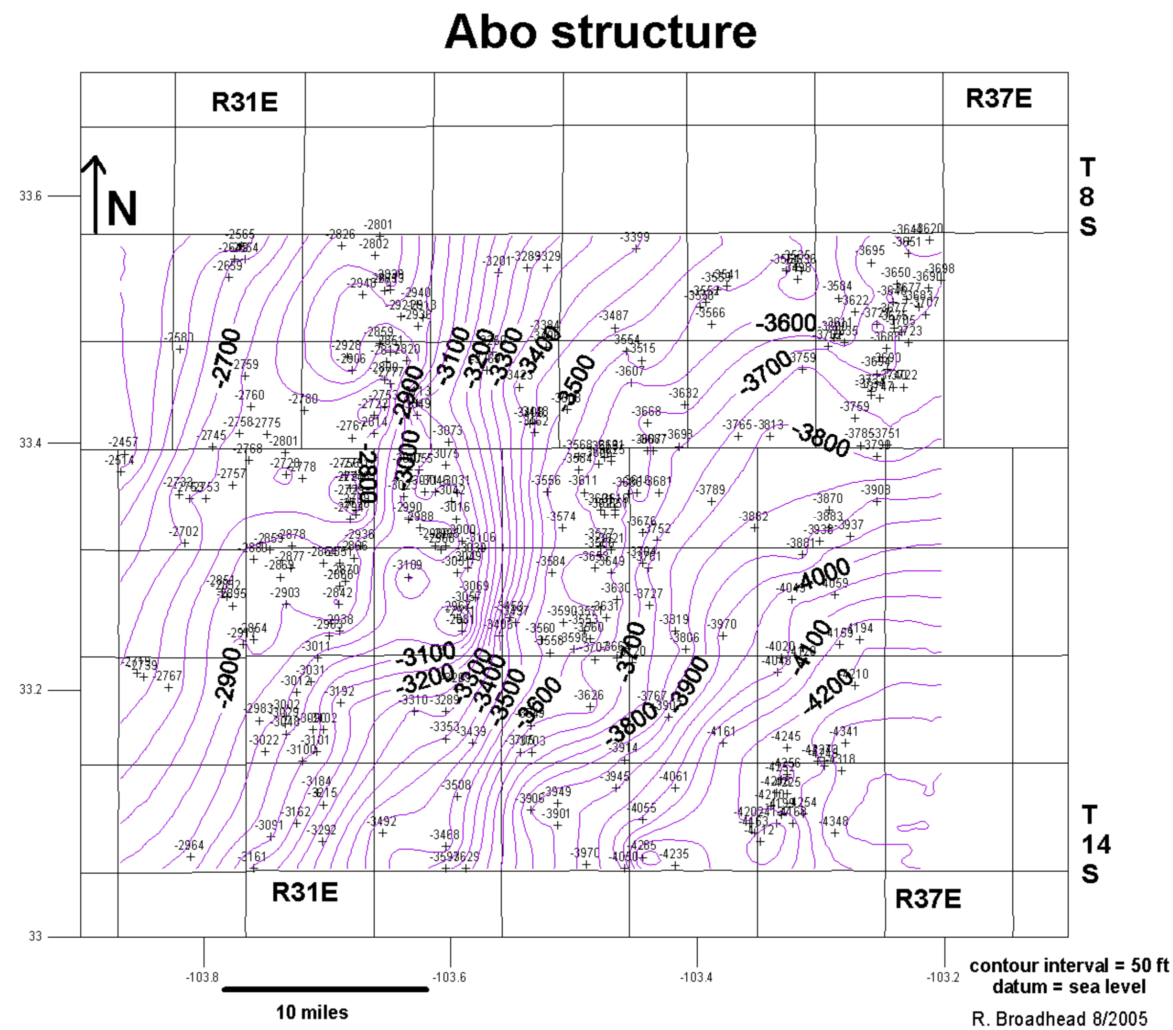


Fig. 3.11. Structure contour map on the upper surface of the Abo Formation (Lower Permian).

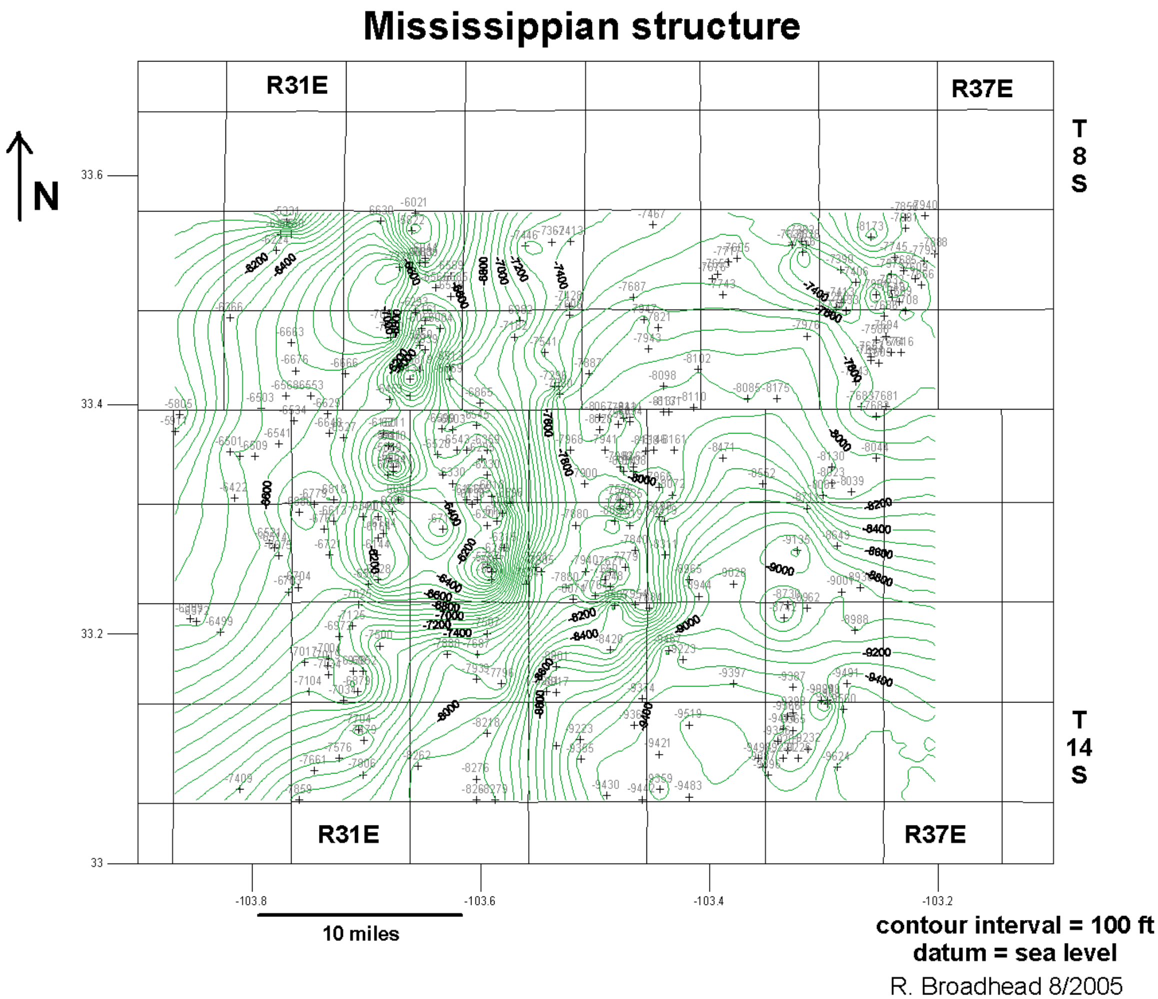


Fig. 3.12. Structure contour map on the upper surface of the Mississippian System.

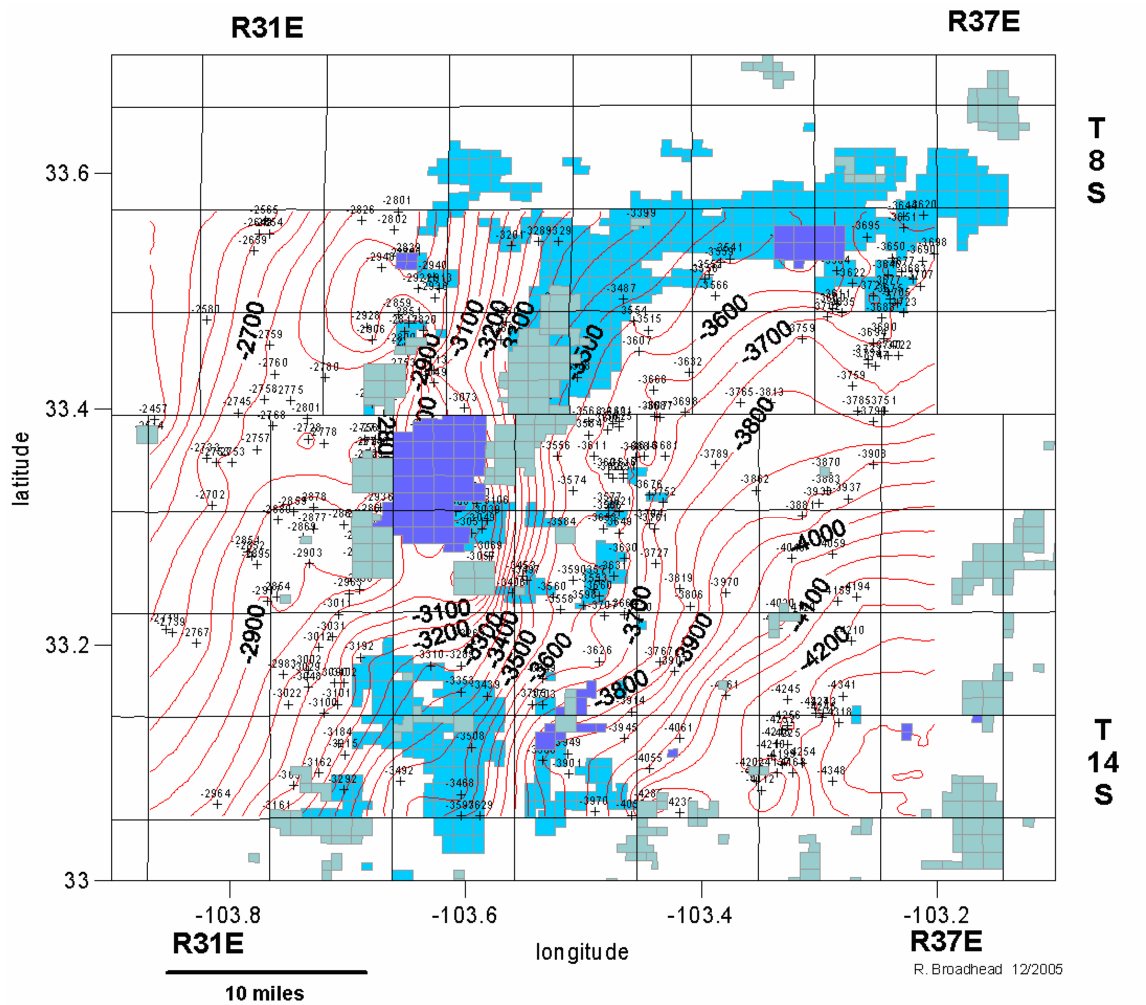


Fig. 3.13. Boundaries of oil reservoirs productive from Permo-Pennsylvanian carbonate reservoirs and structure contours on the upper surface of the Abo Formation.

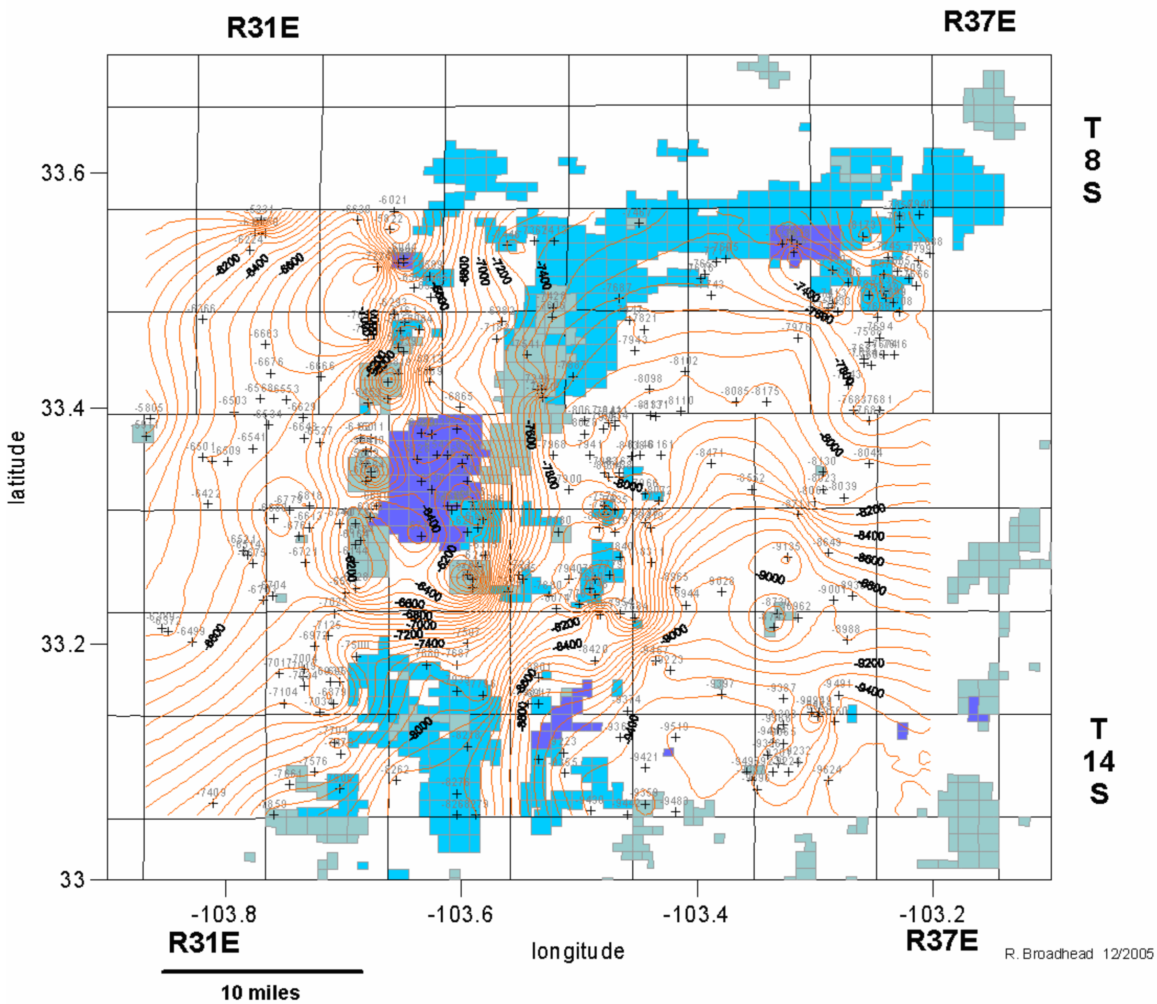


Fig. 3.14. Boundaries of oil reservoirs productive from Permo-Pennsylvanian carbonate reservoirs and structure contours on the upper surface of the Mississippian System.

6. ***Paleostructural mapping and analysis*:** The Pennsylvanian and Early Permian were times of active tectonism and structural deformation in New Mexico [Broadhead, 2001a-c; Kues and Giles, 2004]. During this period of tectonism, numerous structures that together formed the Ancestral Rocky Mountains arose out of the Late Paleozoic seas that covered New Mexico and surrounding areas forming upthrown fault blocks and anticlines that were either emergent islands (if they rose to a sufficient elevation) or bathymetrically high spots on the sea floor. Growth of algal mounds and associated strata that form oil reservoirs in Permo-Pennsylvanian strata is thought to be controlled primarily by location on the tops and flanks of structures that were rising during the deposition of the algal mound

reservoirs [Malek-Aslani, 1985; Cys and Mazzullo, 1985; Cys, 1986; Wahlman, 2001]. Therefore, the mapping and analysis of paleostructures of Pennsylvanian and Early Permian age should be a primary factor in the analysis and prediction of the trends and locations of oil reservoirs in Permo-Pennsylvanian strata.

Timing of the formation of structures and therefore the location of paleostructures is reflected in the thinning of strata deposited in the time period during which the structure was formed. For Ancestral Rocky Mountain paleostructures, this is apparent in the thinning of Pennsylvanian through Lower Permian strata over positive paleostructural elements and the thickening of Pennsylvanian and Lower Permian strata over negative paleostructural elements (Fig. 3.15). Therefore, an isopach map of the interval between the top of the Abo Formation (see Fig. 3.11) and the top of the Mississippian System (see Fig. 3.12) will reveal positive paleostructural elements as enclosed thin areas and negative paleostructural elements as thick areas.

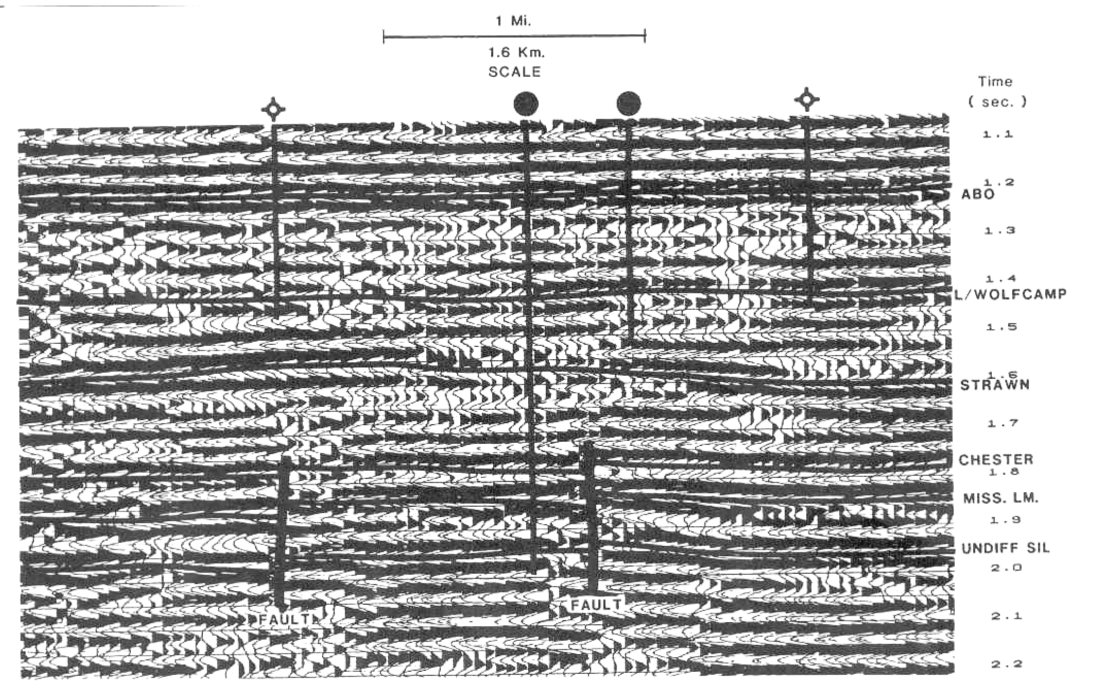


Fig. 3.15. Reflection seismic line across a Permo-Penn algal mound reservoir showing localization of the reservoir over a paleostructure. From Cys (1986)

An isopach map of the interval between the top of the Abo Formation (Lower Permian) and the top of the Mississippian System was prepared with Surfer 8 using the structural data previously acquired (Fig. 3.16). Thin areas denote positive paleostructural elements. Based upon the isopach maps, the axes and directions of plunge of positive paleostructural elements were interpreted and mapped (Fig. 3.17). The Abo-Mississippian isopach map was then overlain on the locations of oil reservoirs that produce from Permo-Penn carbonate strata (Fig. 3.18). As predicted, most, but not all, areas characterized by Permo-Pennsylvanian production coincide with thin areas on the Abo-Mississippian isopach map. Inasmuch as the thin areas represent positive paleostructural elements, it appears that the Abo-Mississippian isopach map, which acts as a proxy for an Ancestral Rocky Mountains paleostructure map, should be a key ingredient for the FEE tool when it comes to predicting the trends and locations of oil reservoirs formed by carbonate stratigraphic traps.

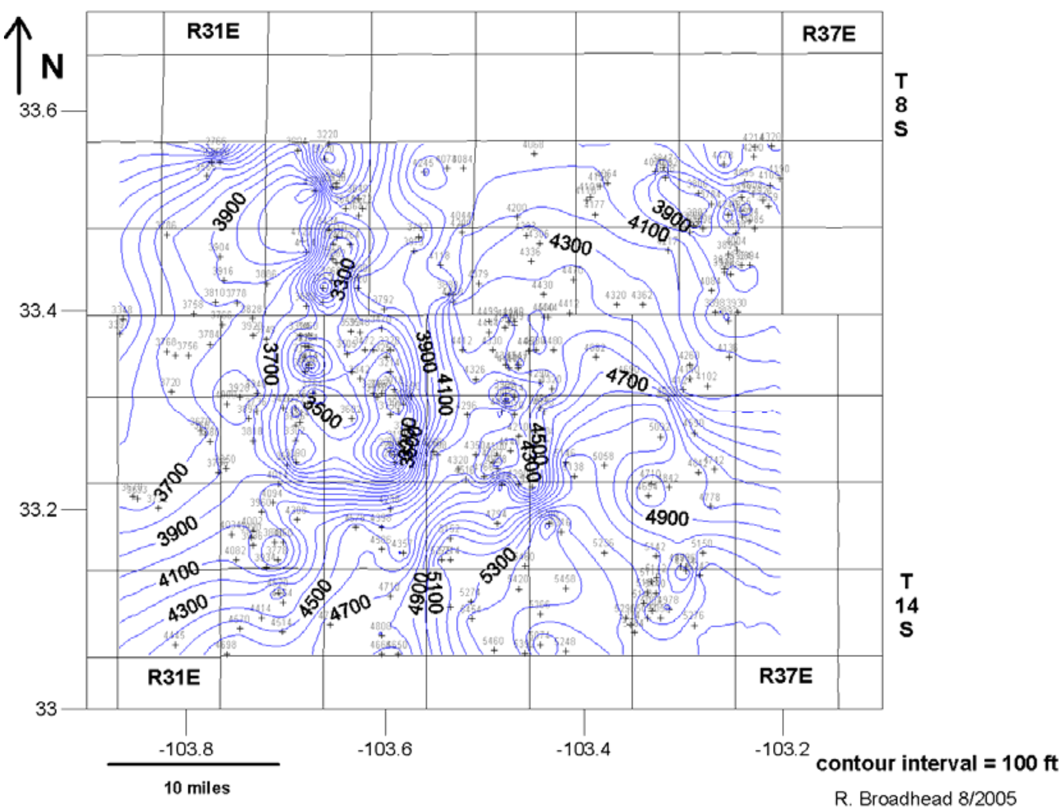


Fig. 3.16. Isopach map of the stratigraphic interval between the top of the Abo Formation (Lower Permian) and the top of the Mississippian System.

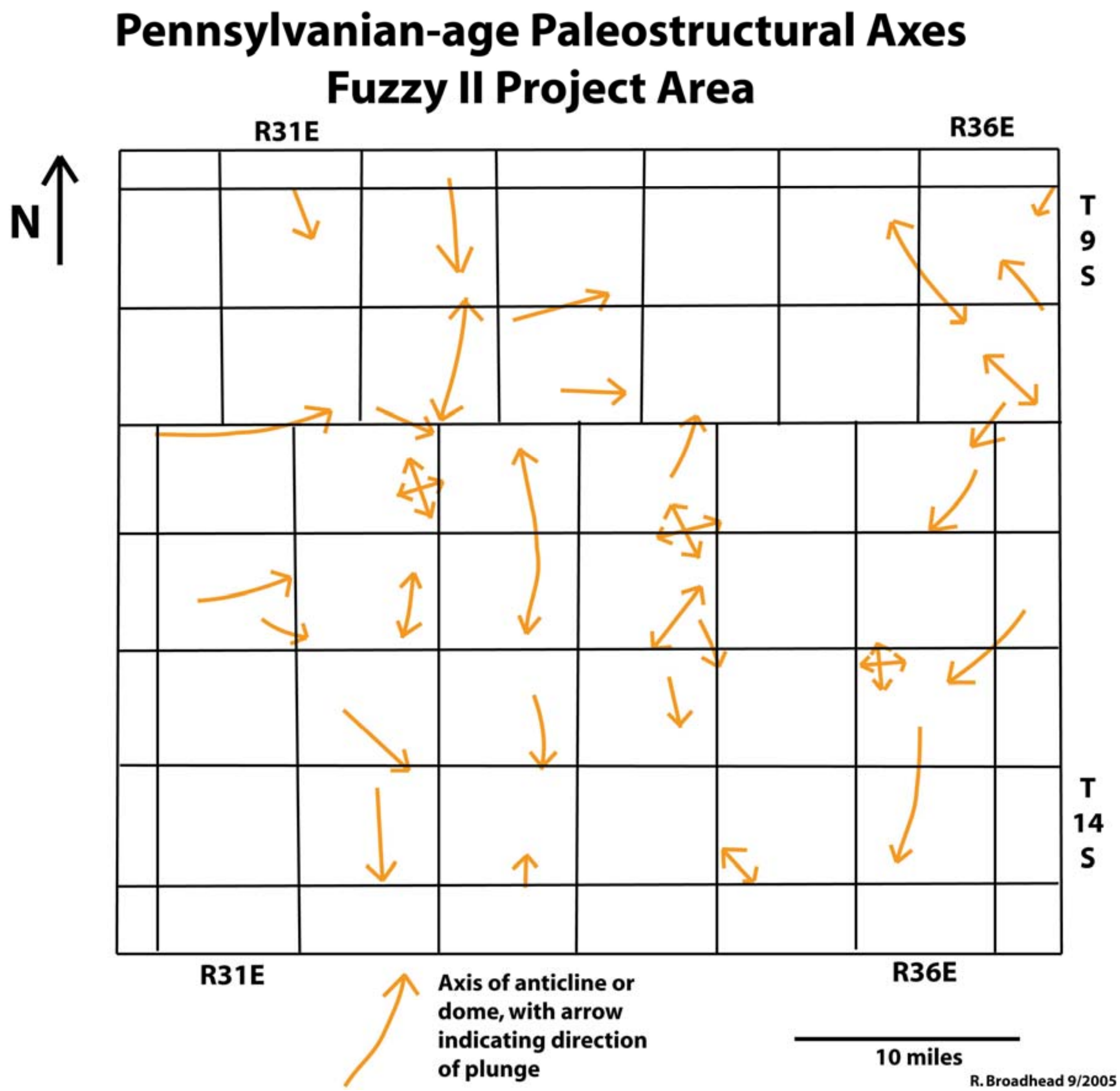


Fig. 3.17. Location of paleostructural positive elements as determined from the Abo-Mississippian isopach map.

The correlation between paleostructure and the locations of oil reservoirs in Permo-Penn strata is not absolute. Examination of Fig. 3.18 reveals indicated paleostructures that have been proven by drilling to be barren of production. Conversely, there are some productive areas that are not associated firmly with paleostructures. It is believed several factors, principally paleo-water depth over the structures, may be responsible for some structures being barren of production. If the paleostructure caused the bottom of the sea floor to rise up too high then water may have been too shallow to sustain significant algal mound growth in the area above the structure; however, in this case, water may have been sufficiently deep over the flanks of the structure to sustain algal mound growth. If the area over the structure was emergent, then it would have been subject to erosion rather than deposition. On the other hand if water depth was too great, conditions such as nutrient and oxygen supply and the amount of sunlight reaching bottom waters would have been incorrect for the growth of algal mounds and associated reservoirs.

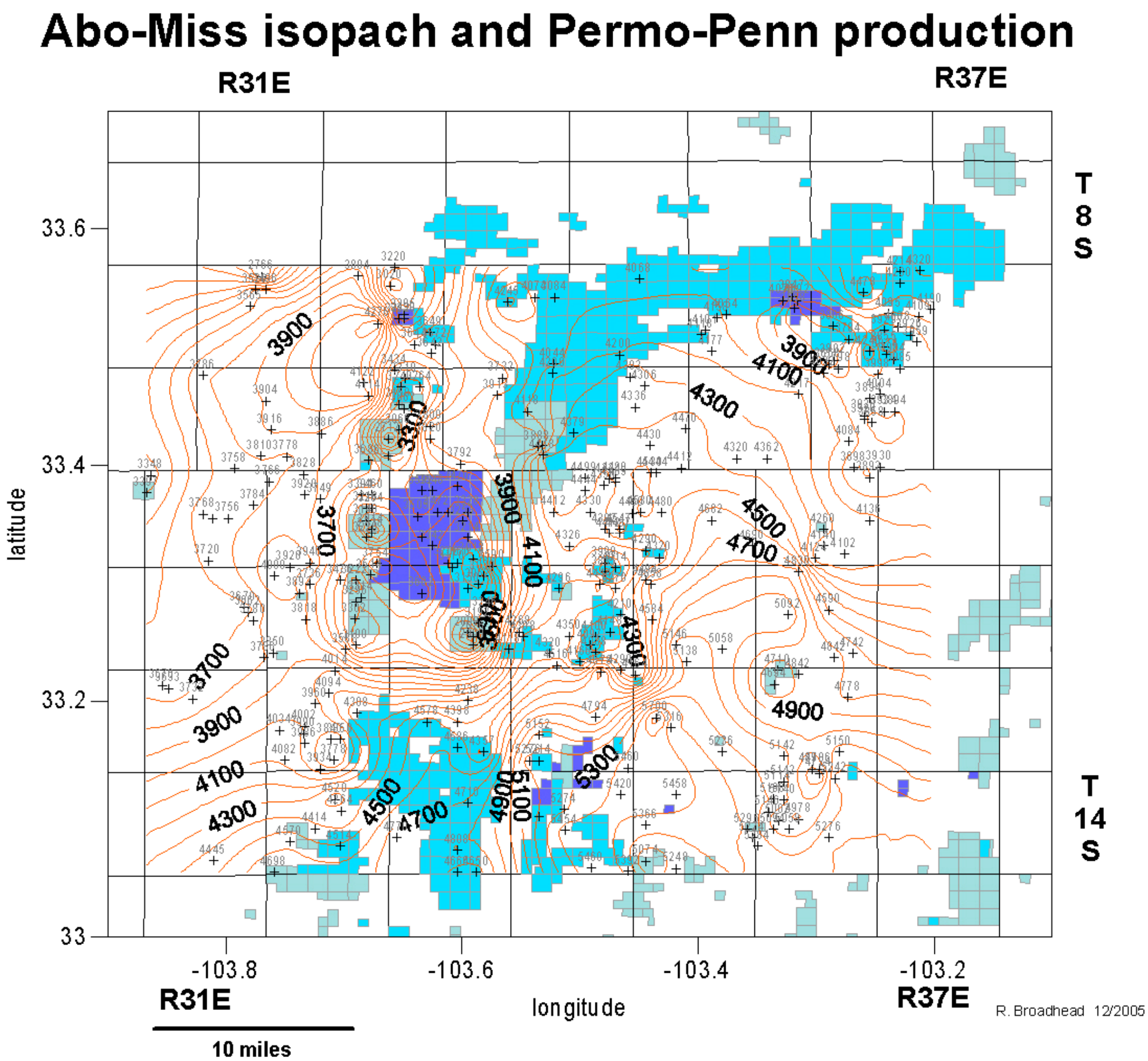


Fig. 3.18. Boundaries of oil reservoirs productive from Permo-Pennsylvanian carbonate reservoirs and isopach map of the stratigraphic interval between the top of the Abo Formation and the top of the Mississippian System.

Second Project Year

During the period from January 2006 through December 2006, geologic data acquisition and analysis continued and was completed on the Upper Pennsylvanian and Lower Permian carbonate reservoirs within the project areas in the Permian Basin of southeastern New Mexico (Figs. 3.1–3.3). During 2006, work on the Bough intrashelf project area was completed. Geologic data was acquired, mapped and analyzed on a-second project area, the shelf-margin project area that includes the Upper Pennsylvanian Dagger Draw oil reservoirs.

The second project area was added to diversify the expert system's approach to prospecting for oil in carbonate stratigraphic traps. Although reservoirs in both areas are formed primarily by phylloid algal mounds that have seen multiple episodes of diagenesis, the reservoirs within the Bough intrashelf area grew on bathymetrically high paleostructures and the reservoirs within the shelf-margin area grew primarily as bioherms on a constructional shelf-margin; their geographic location does not appear to be related to paleostructures.

Both of the project areas have significant production. The 58 Permo-Pennsylvanian reservoirs that are at least partially present within the Bough intrashelf project area have produced a combined total of 329 million bbls oil (MMBO; Table 3.1). The 24 Upper Pennsylvanian reservoirs within the shelf-margin project area have produced a combined total of 83 million bbls oil (Table 3.3). The reservoirs from the intrashelf project area are located within the Permo-Pennsylvanian age Bough zone.

During the second project year (calendar year 2006), additional stratigraphic data were acquired for the intrashelf project area as well as detailed production data for individual wells. Additionally, a small amount of petrographic data from reservoir cores was acquired so that relationships of diagenetic reservoir development to paleostructure could be discerned. Geologic data pertaining to structure, paleostructure, and the stratigraphic environments relevant to oil and natural gas production in the shelf-margin project area were obtained from well records and by analyzing and correlating electric and radioactivity logs from 312 wells within the 720 mi^2 region. Although additional data acquisition and analysis would no doubt result in improved operation of the expert system in reservoir types of the shelf-margin project area, termination of the project at the end of 2006 necessitated an early finish to the project and therefore a premature end to data acquisition and analysis. Further discussion on data acquisition, mapping and analysis is subdivided below into sub-discussions on the Bough intrashelf area and the Dagger Draw shelf-margin area.

Bough Intrashelf Project Area

Project Tasks – Geologic Data and Acquisition

Geologic data, production data, and well data for the work performed in the Bough intrashelf project area may be found in the following databases (attached in Appendix II):

1. ***Bough greater area.xls***: contains well data and geologic data for the 300 wells used to map and analyze the entire project area (Fig. 3.5)
2. ***Bough detailed area.xls***: contains well data, geologic data and production data for the portion of the project area selected for more detailed and comprehensive work.

The following tasks were enjoined during the second project year:

7. ***Compiled cumulative production data*** on Bough (Permo-Pennsylvanian) carbonate reservoirs within the project area and mapped the data.
8. ***Stratigraphic data acquisition in wells:*** Refined correlations of productive Bough carbonate zones in 224 wells within the detailed part of the project area.
9. ***Stratigraphic data mapping and analysis*:** Made final isopach maps of productive Bough carbonate reservoir zones in the detailed part of the project area and related production to the isopach maps.
10. ***Structural data mapping and analysis*:** Constructed structure contour maps of the upper surface of the Bough A, Bough B, Bough C, and Bough D zones within the project area and related structure to production from Bough carbonate reservoirs.

11. ***Paleostructural mapping and analysis*:** During the first project year, structural data on multiple formations were used to create a paleostructure map of positive tectonic elements that were formed concurrently with deposition of Bough reservoirs. Positive paleostructural elements were related to production from Permo-Pennsylvanian carbonate reservoirs. Additional, significant data analysis was performed during 2006.
12. ***Reservoir analysis:*** Described and analyzed cores and thin sections of cores from productive and non-productive reservoir strata in the Bough zones in order to determine factors that control porosity development and to better relate reservoir locations to paleostructures within the project area.

Each of these tasks is discussed more fully below and maps produced as a result of tasks are presented.

7. ***Compiled production and stratigraphic data on Bough (Permo-Pennsylvanian) carbonate reservoirs within the project area.*** Reservoir-wide cumulative and annual oil production data and stratigraphic data were compiled for the 83 designated oil and gas reservoirs that produce from Permo-Penn carbonate reservoirs within the boundaries of the project area (Fig. 3.19; Table 3.1). Because New Mexico cumulative production figures are not always accurate after the year 1993, the annual production data after 1993 were added to the cumulative total for reservoirs that are either wholly or partially present within the Bough intrashelf project area. Details of the problems with published post-1993 cumulative production data are given in Broadhead et al. (2004) and Dutton et al. (2005). A database was also produced for 224 wells within a more detailed subsection of the project area (Figs. 3.20, 3.21) that includes cumulative oil, gas and water production data for each well (again calculated by adding annual production data for years after 1993 to the published 1993 cumulative numbers), depth of perforated productive reservoirs, a summary of pertinent completion information for nonproductive wells, which Bough zone is productive in the well, and geologic data obtained from the correlations. Contour maps of cumulative oil

production per well were prepared for the entire Bough formation (Fig. 3.22) and for the Bough C member (Fig. 3.23), which is the most productive Bough member (See Table 3.2 for production data from the 241 wells).

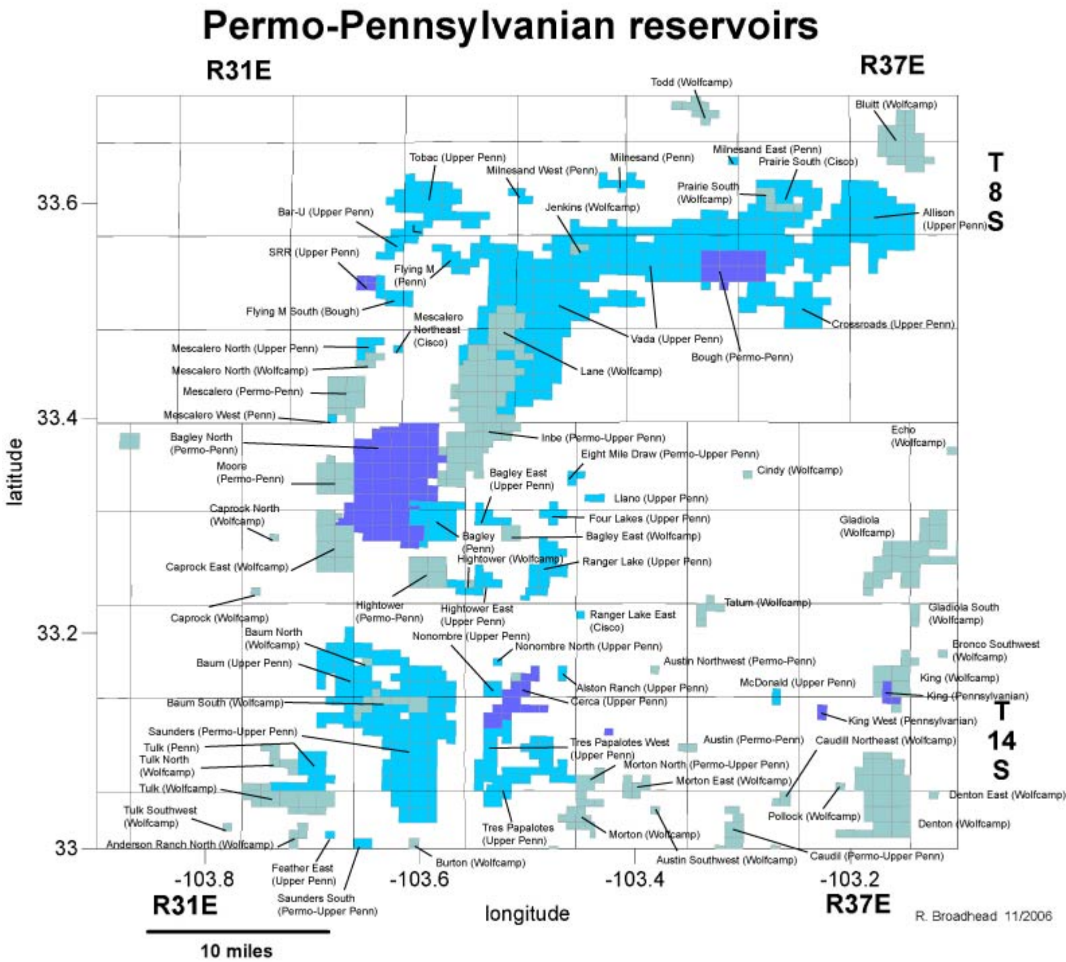


Fig. 3.19. Reservoirs productive from Upper Pennsylvanian and Lower Permian carbonates in the Bough intrashelf project area.

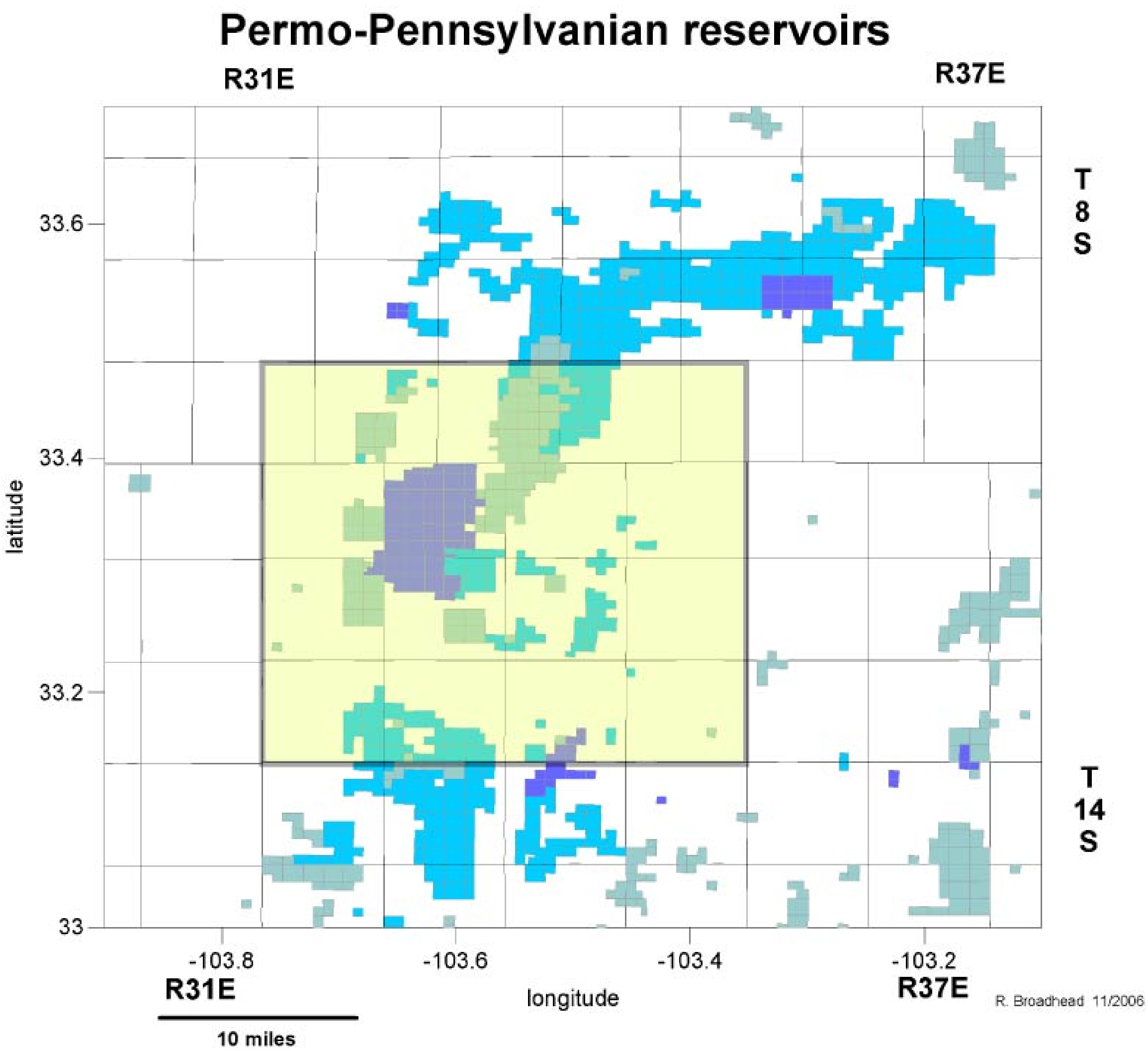


Fig. 3.20. Location of the area selected for more detailed analysis of the Bough formation. The detailed work in this area was undertaken by graduate student Jake Sharp.

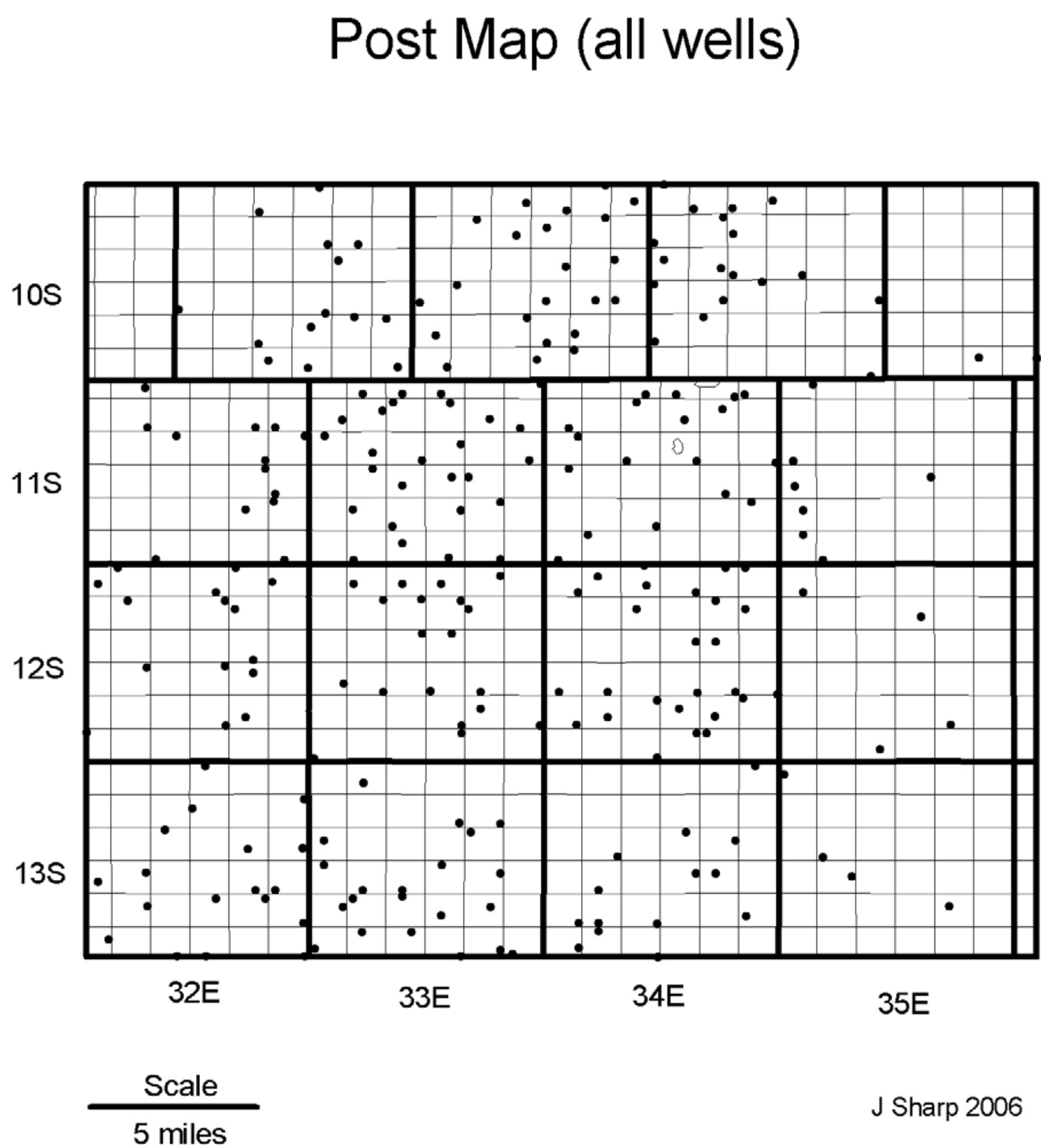


Fig. 3.21. Location of wells used for geologic and production analysis in the detailed project area.

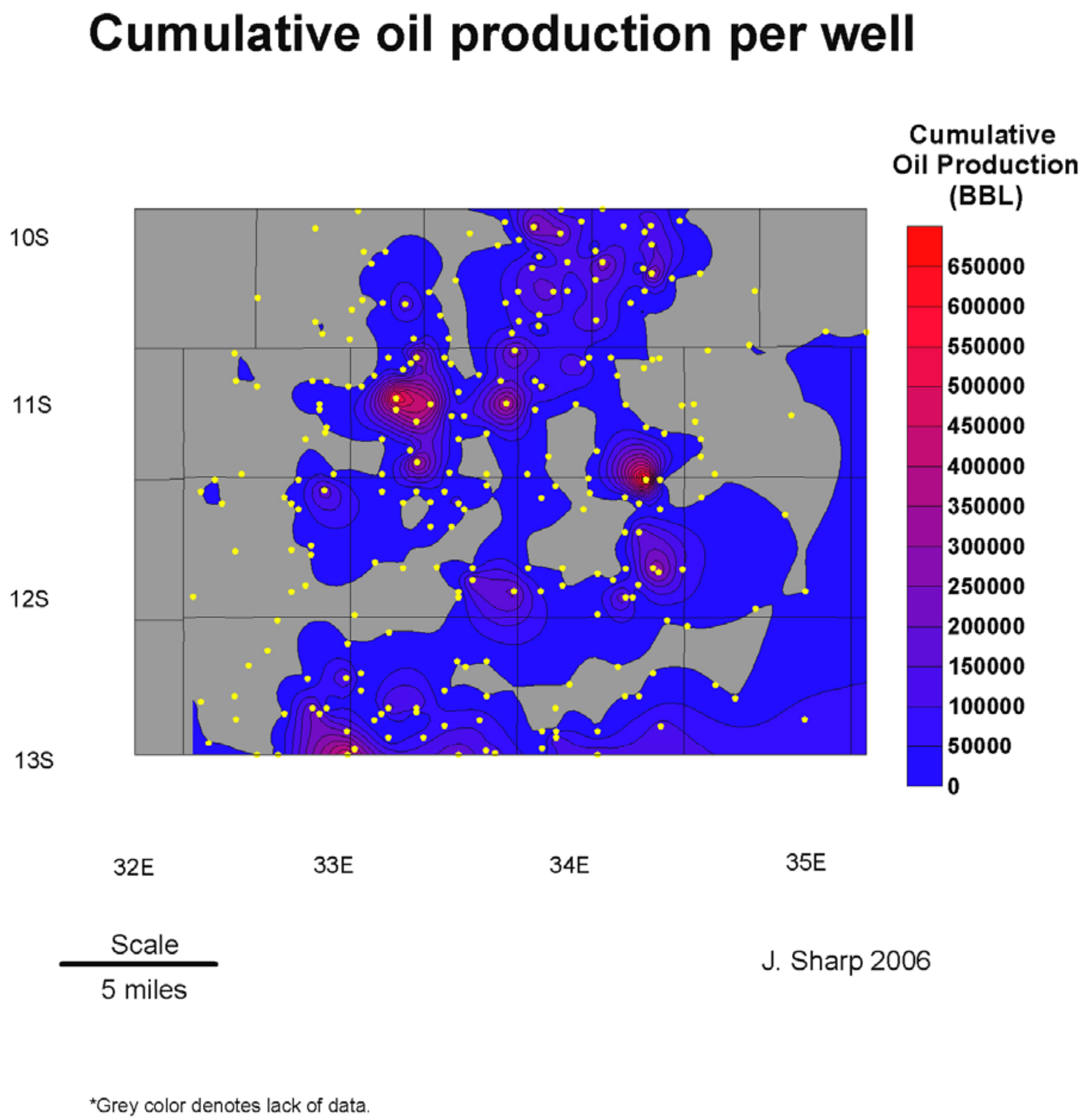


Fig. 3.22. Contour map of cumulative oil production from wells productive from the Bough A, Bough B, Bough C, and Bough D zones in the detailed project area.

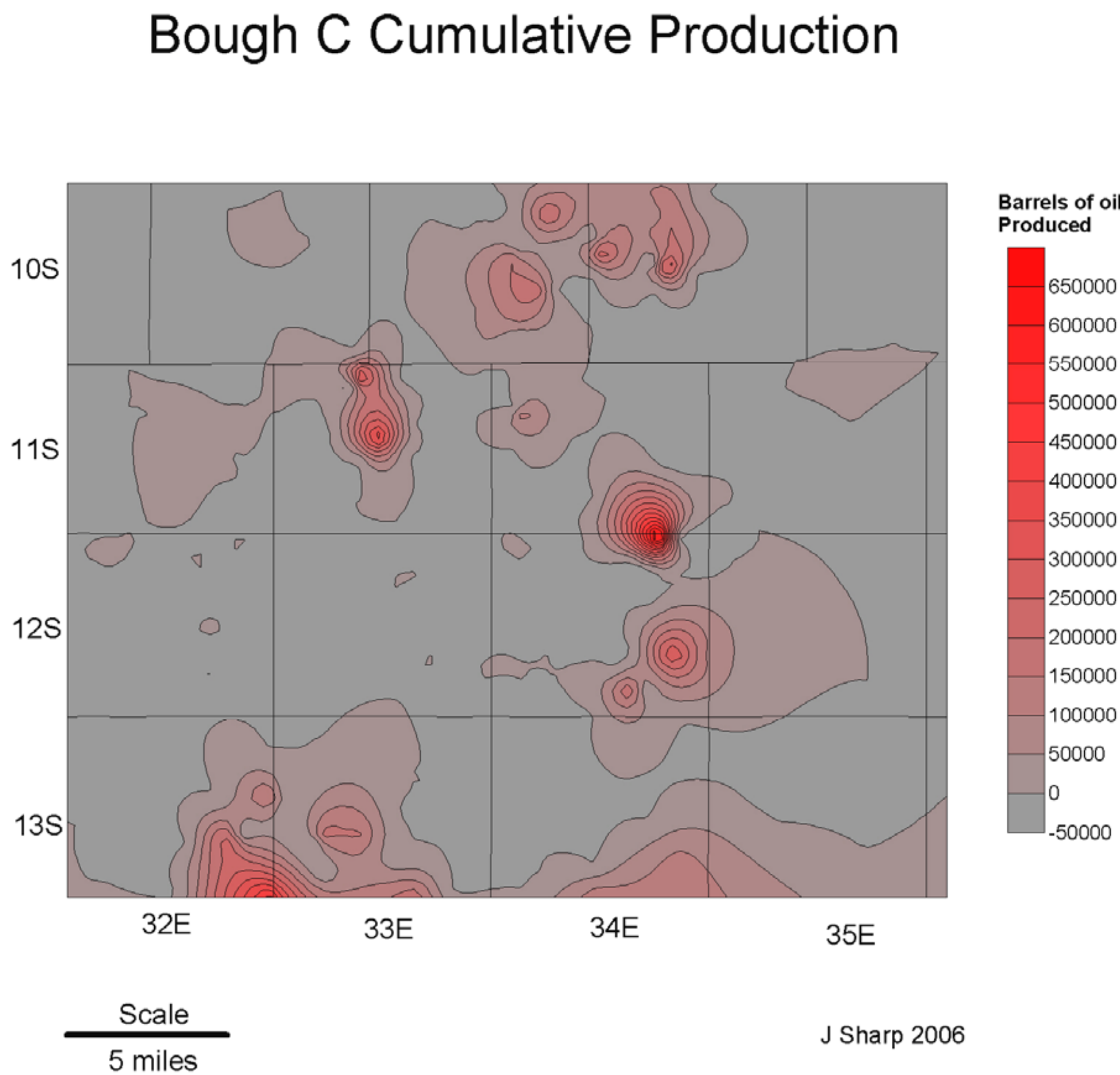


Fig. 3.23. Contour map of cumulative oil production from wells productive from the Bough C zone in the detailed project area.

Table 3.2. Cumulative Oil, Gas and Water Production Data for the 241 Wells Analyzed in the Detailed Study Area*

	Bough A	Bough A + B	Bough B	Bough B + C	Bough C	Bough C + D	Bough D	Bough A + B + C + D	Totals
Cumulative oil, bbls	554323	340623	419428	719475	4032341	2439081	1282871	169222	***9957364***
% oil	5.57%	3.42%	4.21%	7.23%	40.50%	24.50%	12.88%	1.70%	***100.00%***
Cumulative gas, MCF	1637370	391337	896582	3692646	6850480	3165094	4942738	165689	***21741936***
% gas	7.53%	1.80%	4.12%	16.98%	31.51%	14.56%	22.73%	0.76%	***100.00%***
Cumulative water, bbls	704903	865800	394348	1474241	6924880	2523138	1984326	170960	***15042596***
% water	4.69%	5.76%	2.62%	9.80%	46.04%	16.77%	13.19%	1.14%	***100.00%***
Number of wells	5	4	5	4	30	8	14	1	***71***

* includes cumulative production and percent of total production obtained from the Bough A, Bough B, Bough C and Bough D zones. Cumulative production totals are only applicable to the 241 wells (71 of which were productive from the Bough), but percentages of production from each of the Bough members are thought to be representative for all Bough reservoirs in the project area.

8. ***Stratigraphic data acquisition in wells:*** Productive Bough carbonate zones were correlated in 224 wells throughout a subsection of the project area. Where penetrated by wells, the tops of the Bough A, Bough B, Bough C and Bough D members (Fig. 3.4) were correlated with gamma ray, resistivity, and other borehole logs. Inasmuch as the traps that form oil reservoirs in Bough strata are largely stratigraphic (see Broadhead, 1999a, b; Cys, 1986; Cys and Mazzullo, 1985; Malek-Aslani, 1985; Wahlman, 2001), the acquisition of reliable, consistent, and accurate stratigraphic data is essential to the geologic analysis of reservoirs and traps. In order to ensure adequate, consistent and correct correlations, 14 reference cross sections had been produced throughout the project area utilizing 126 wells during the first (2005) project year (Fig. 3.5). The wells were rigorously correlated into closed loops so as to eliminate correlation inconsistencies and errors; these correlations were reevaluated and revised where necessary in 2006 and additional wells were correlated to obtain as even a density of data as existing (e.g. already drilled) wells allow. The latitude and longitude of the well locations were calculated using a digital land grid and *Geographix* software (*Geographix* is a registered trademark of Landmark Graphics, Inc.) that

uses the digital land grid to convert surveyed footage measurements of wells from section boundaries into latitude and longitude. Well names, locations and depths to the tops of the Bough A, Bough B, Bough C and Bough D members were entered into an Excel database. Maps made with data from the additional wells will reveal variations in stratigraphy that may be related to the localization of hydrocarbon traps. In total, the tops of the Bough A, Bough B, Bough C and Bough D were correlated in 224 wells.

9. ***Stratigraphic data mapping and analysis*****:** Digital isopach maps were made of the Bough A, Bough B and Bough C members using all wells within the area of detailed investigation (Figs. 3.24–3.26). These maps were produced using *Surfer 8,* a modern and sophisticated contouring program (*Surfer 8* is a registered trademark of Golden Software, Inc.). Data were gridded with a kriging method. The boundaries of oil pools productive from the Permo-Penn carbonate reservoirs were superimposed upon the isopach maps (Figs. 3.27–3.29). Additional isopach maps were prepared that indicate which of the 224 wells have been productive from the mapped Bough member (Figs. 3.30–3.32).

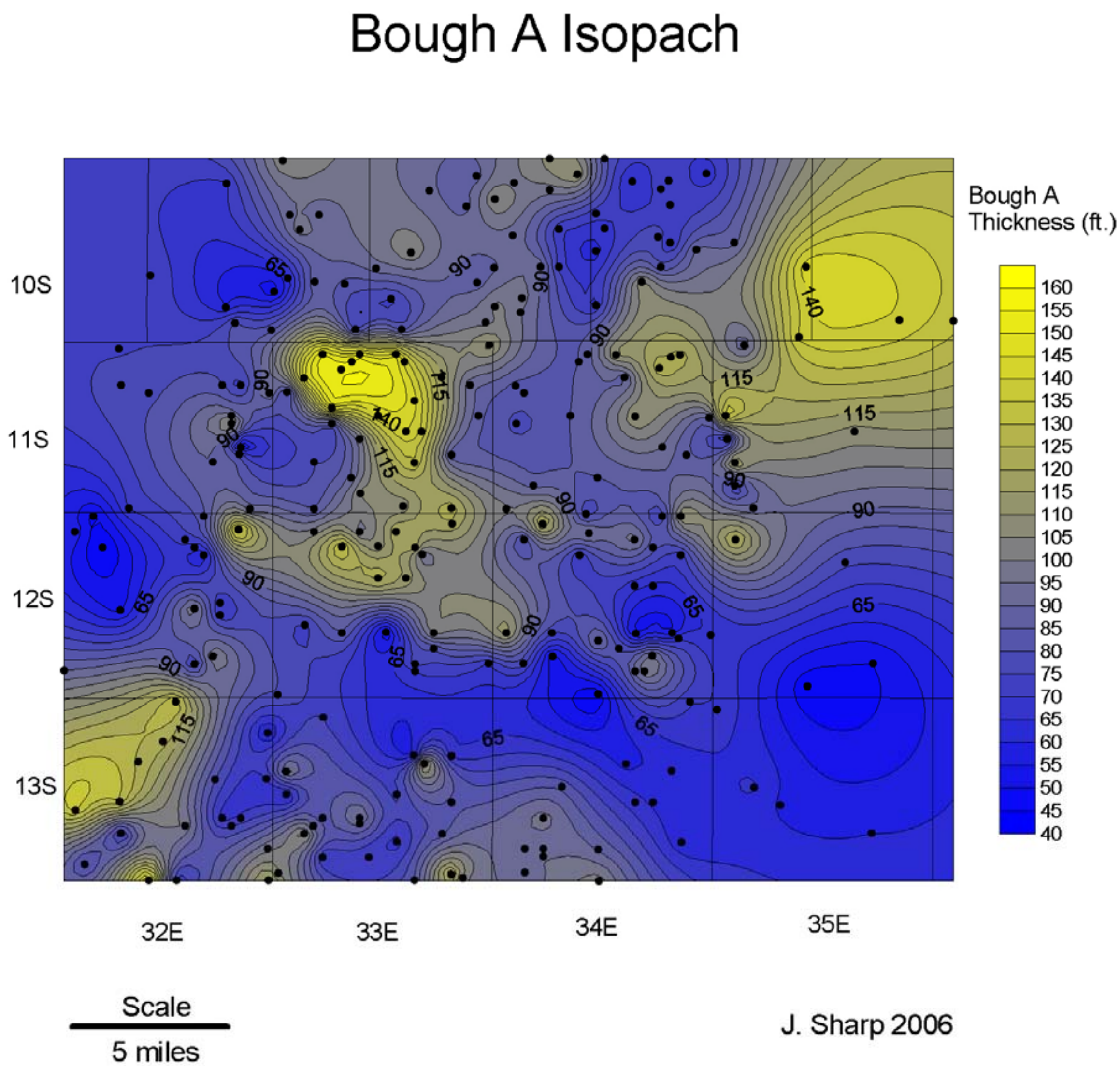


Fig. 3.24. Isopach map of the Bough A member, detailed project area. Contours in feet.

Bough B Isopach

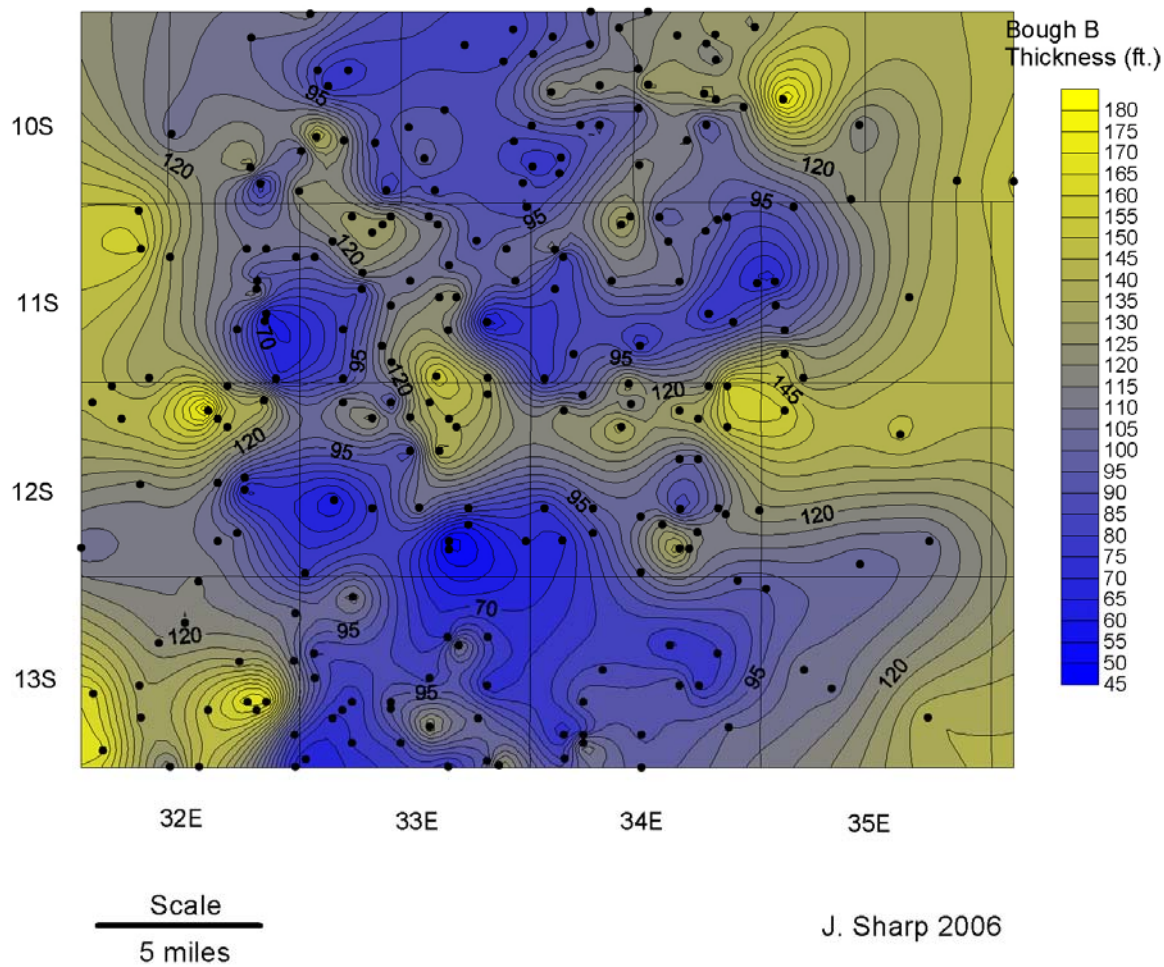


Fig. 3.25. Isopach map of the Bough B member, detailed project area. Contours in feet.

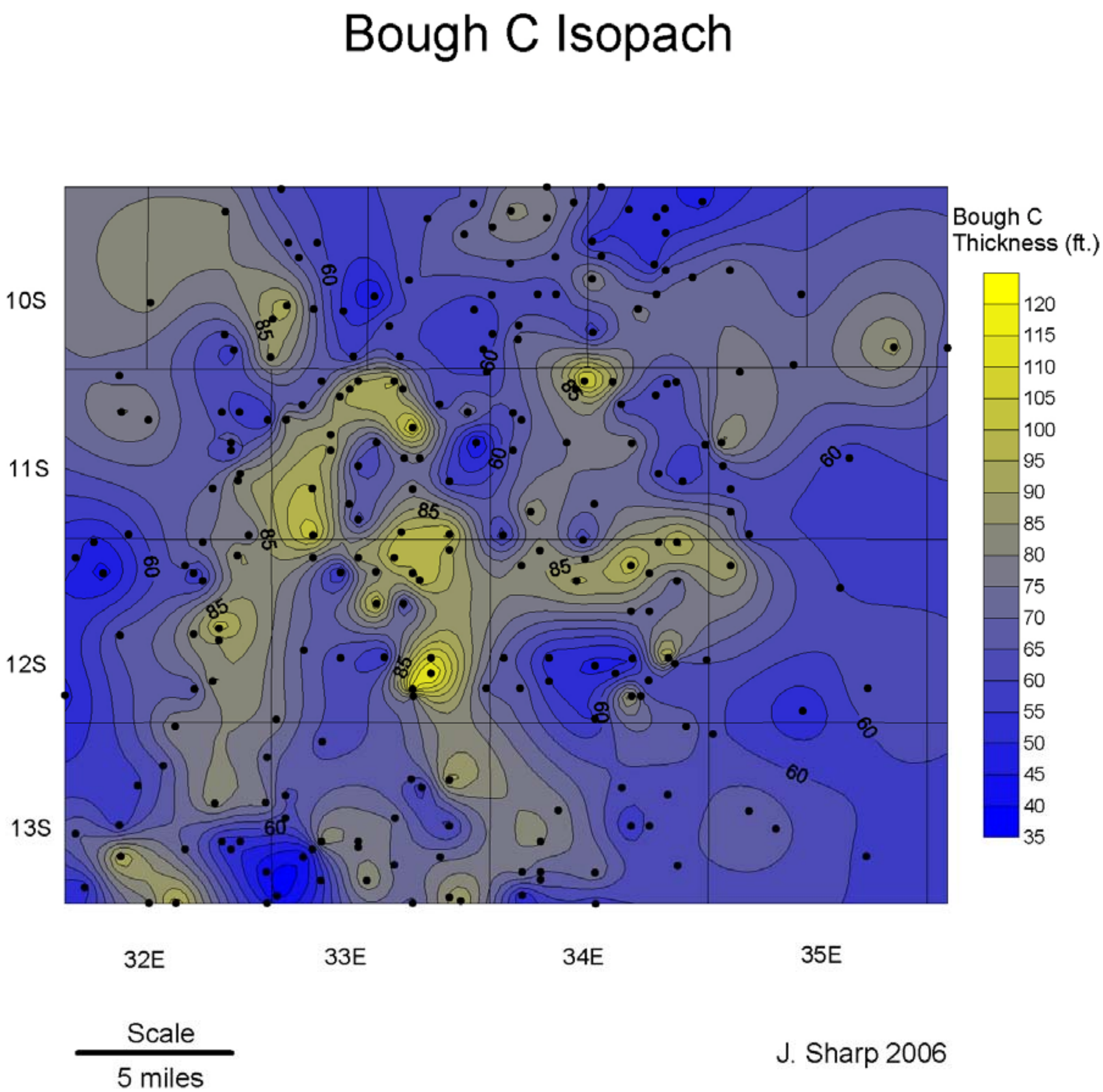


Fig. 3.26. Isopach map of the Bough C member, detailed project area. Contours in feet.

Bough A Isopach

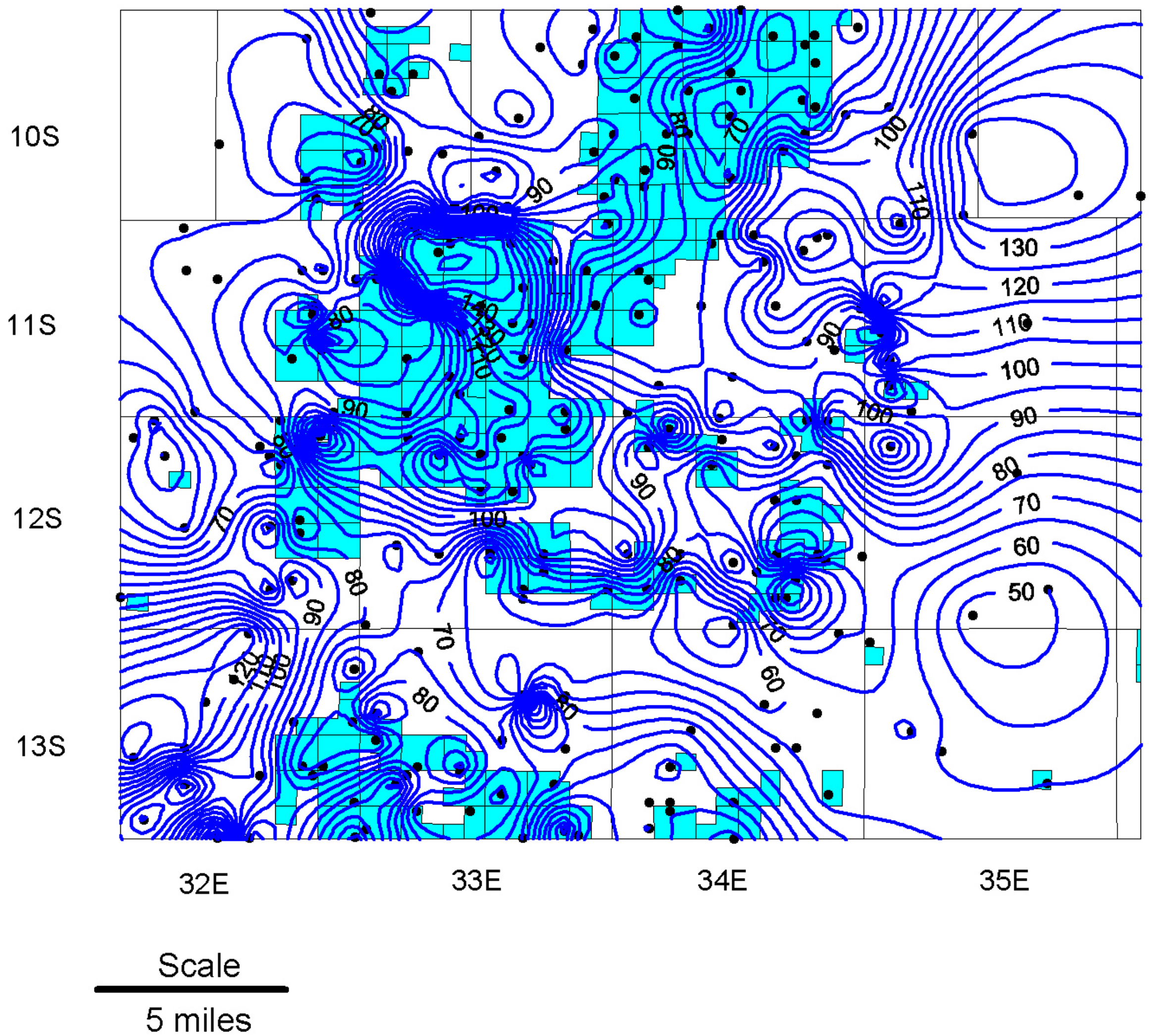


Fig. 3.27. Isopach map of the Bough A member, detailed project area with boundaries of reservoirs productive from Upper Pennsylvanian and Lower Permian strata superimposed. Contours in feet.

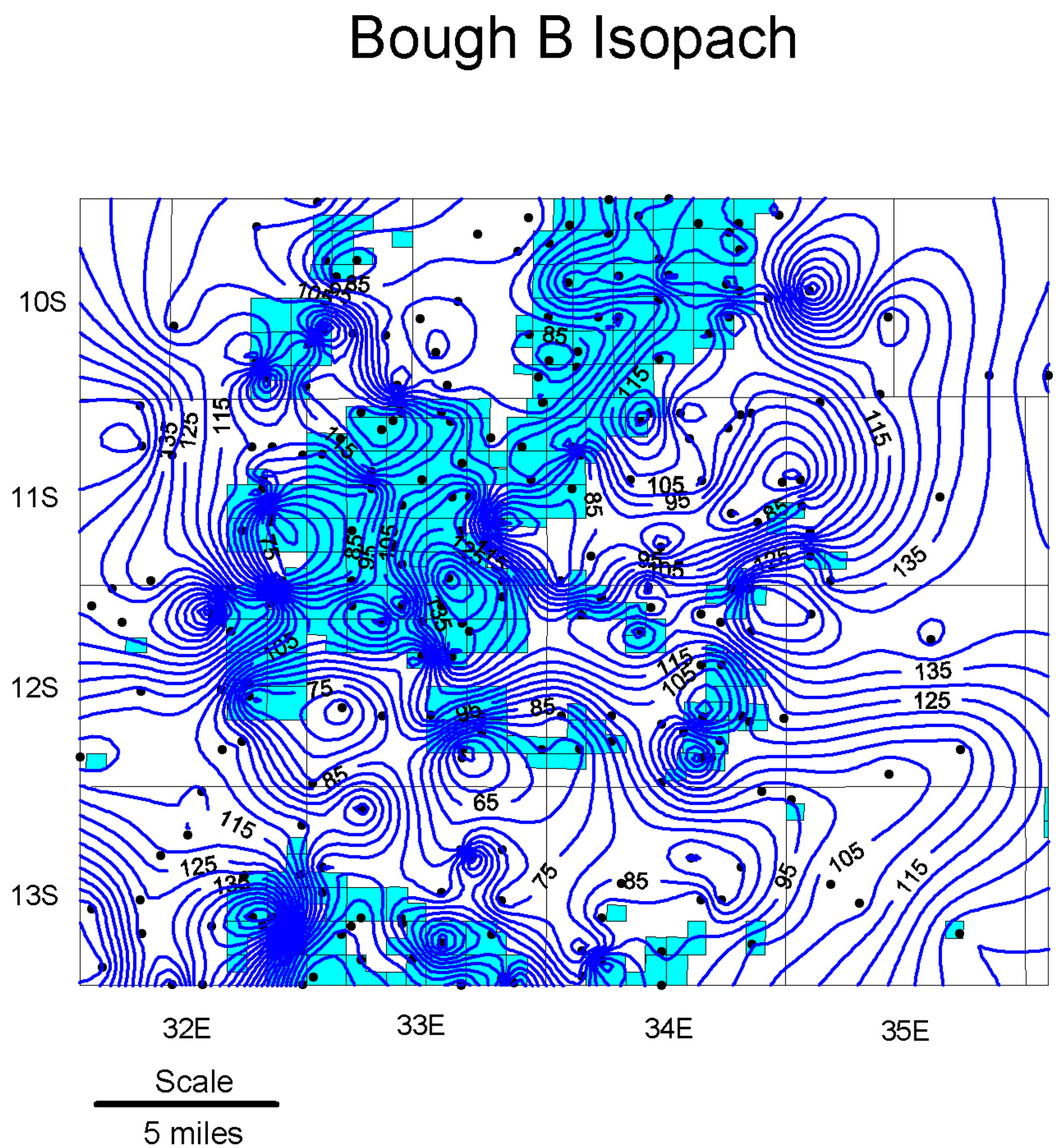


Fig. 3.28. Isopach map of the Bough B member, detailed project area with boundaries of reservoirs productive from Upper Pennsylvanian and Lower Permian strata superimposed. Contours in feet.

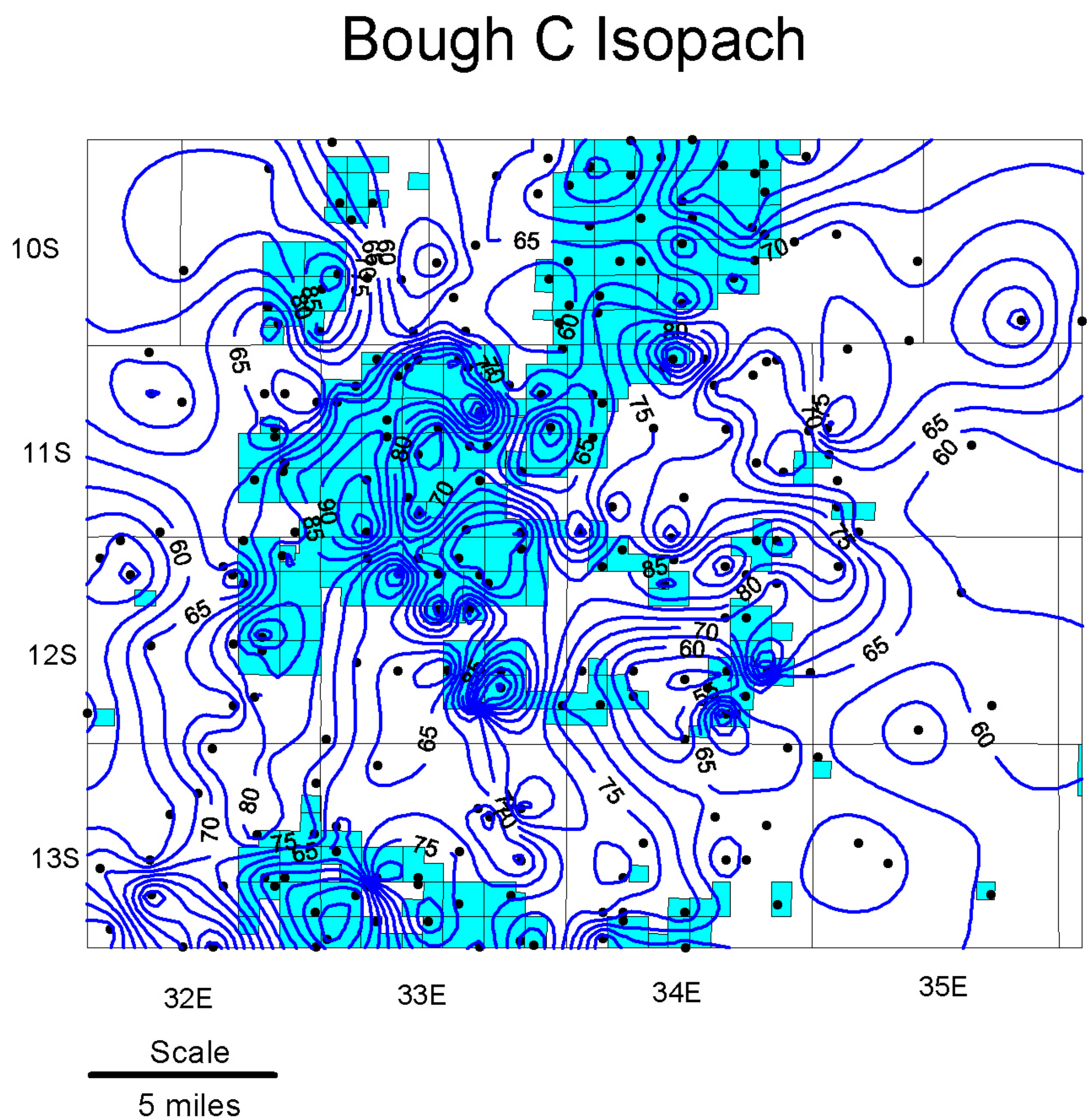


Fig. 3.29. Isopach map of the Bough C member, detailed project area with boundaries of reservoirs productive from Upper Pennsylvanian and Lower Permian strata superimposed. Contours in feet.

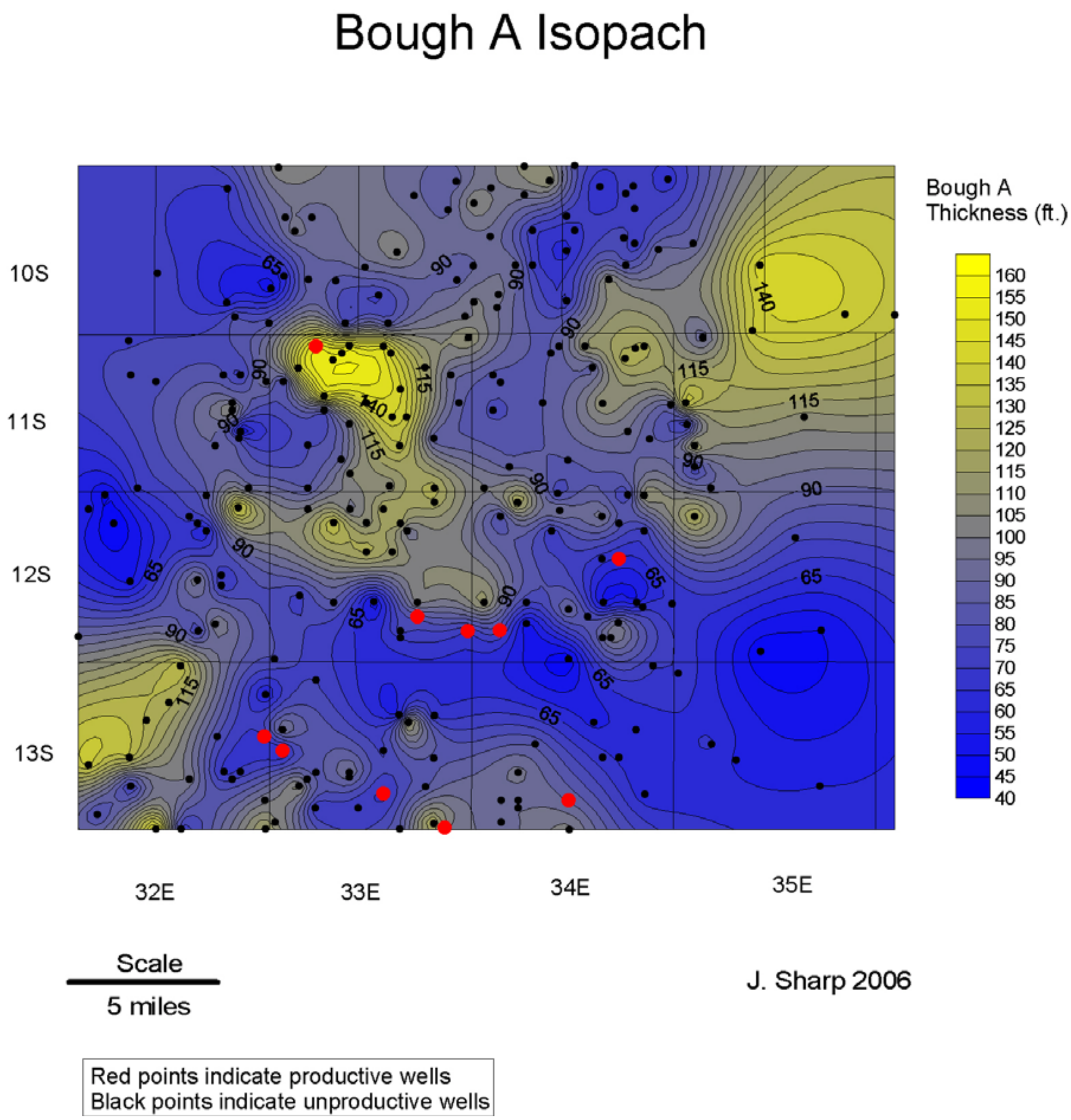


Fig. 3.30. Isopach map of Bough A member. Dots indicate wells used to construct the map. Red symbols indicate wells productive from the Bough A; black symbols indicate wells that are not productive from the Bough A. Contours in feet.

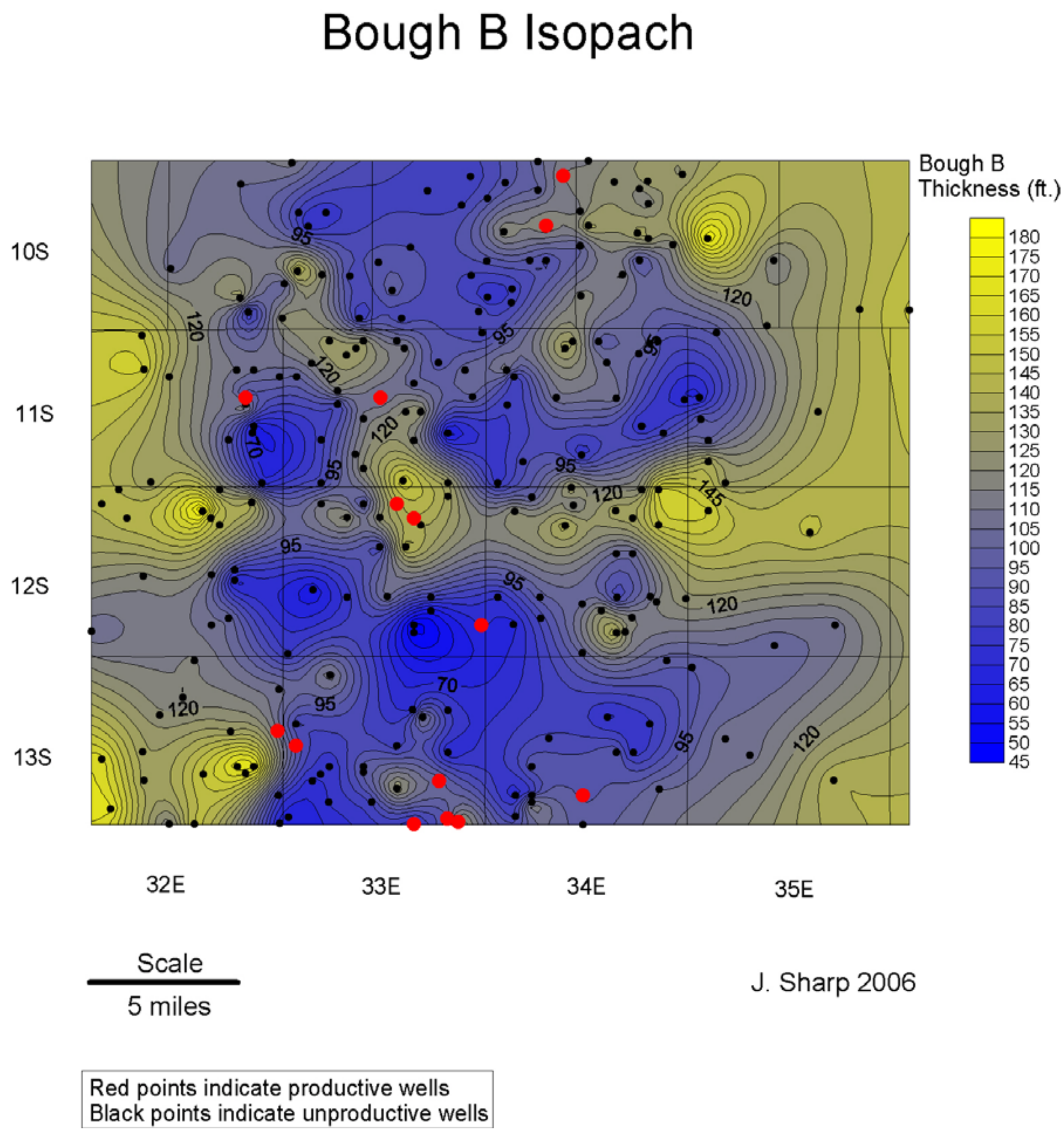


Fig. 3.31. Isopach map of Bough B member. Dots indicate wells used to construct the map. Red symbols indicate wells productive from the Bough B; black symbols indicate wells that are not productive from the Bough B. Contours in feet.

Bough C Isopach

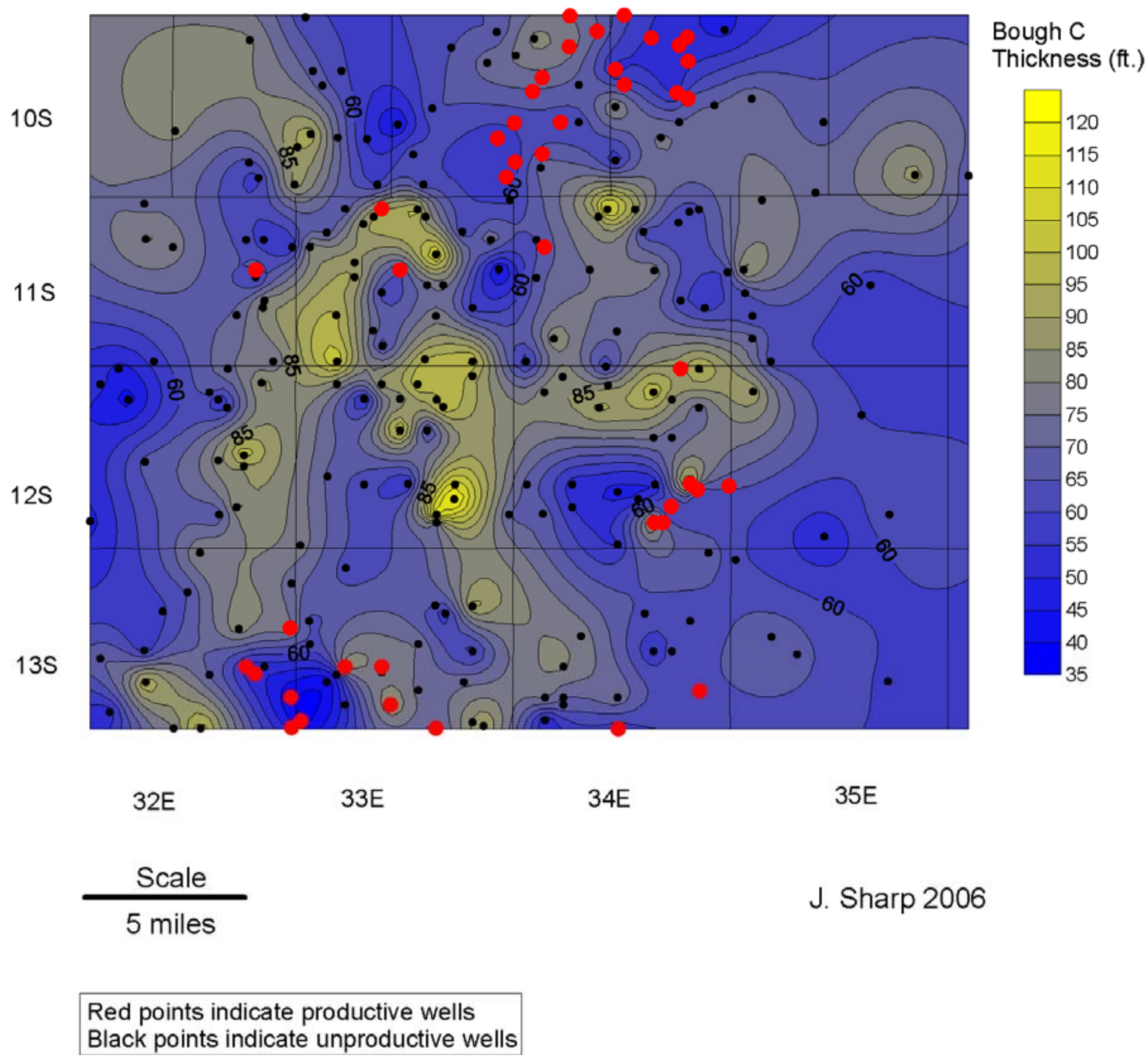


Fig. 3.32. Isopach map of Bough C member. Dots indicate wells used to construct the map. Red symbols indicate wells productive from the Bough C; black symbols indicate wells that are not productive from the Bough C. Contours in feet.

10. ***Structural data mapping and analysis*:** Digital structure contour maps were prepared with *Surfer 8* for the upper surfaces of the Bough A, B, C and D members in the area selected for more detailed investigation (Fig. 3.20). Structure maps of the Abo Formation (Fig. 3.12) and the Mississippian System (Fig. 3.11) had been prepared during the first project year (2005); in the second year, the boundaries of oil pools productive from the Permo-Pennsylvanian carbonate reservoirs were superimposed upon the structure maps (Figs. 3.33–3.34). Additional structure maps of the Bough A, B and C members were prepared that indicate which of the 224 wells have been productive from the mapped Bough members (Figs. 3.35–3.37). No exact correlations between the Abo structure map and the locations of oil reservoirs are apparent. However, there is a general correlation between the locations of oil reservoirs and closed contours delimiting positive areas on the Mississippian structure map.

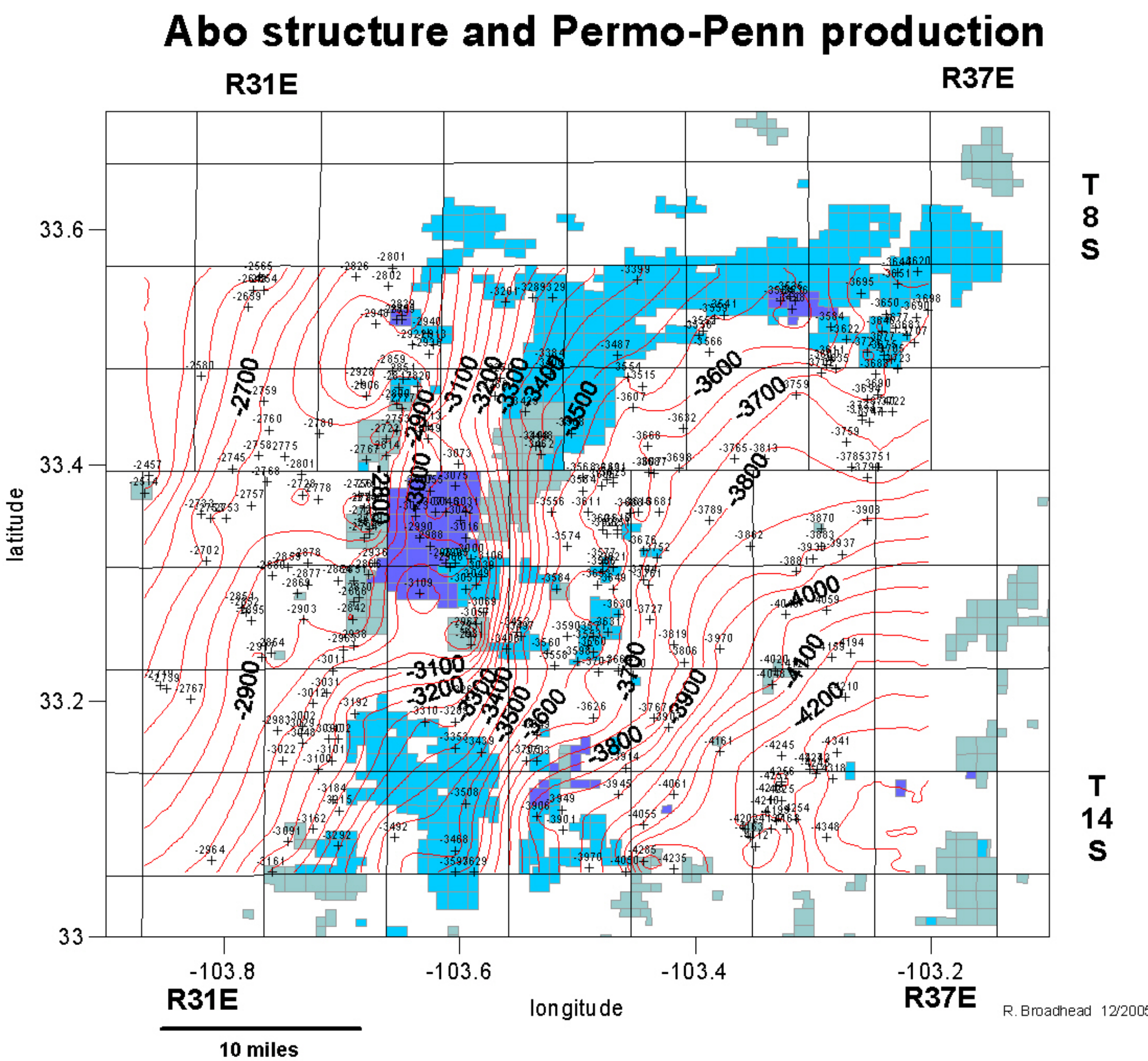


Fig. 3.33. Structure contours on top of Abo Formation (Lower Permian), Bough intrashelf project area with boundaries of reservoirs productive from Upper Pennsylvanian and Lower Permian strata superimposed. Contours in feet. Datum = sea level.

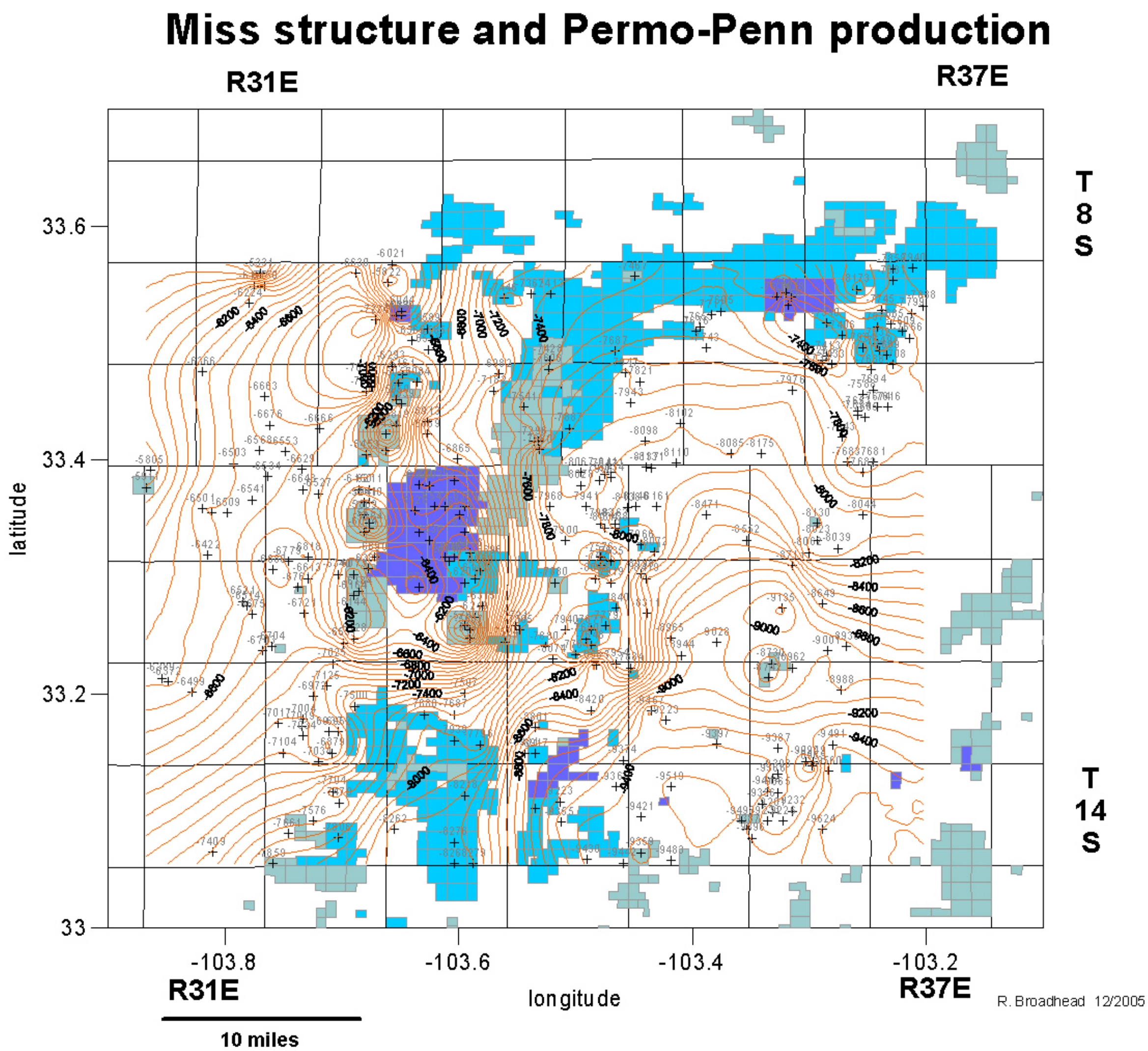


Fig. 3.34. Structure contours on top of the Mississippian System, Bough intrashelf project area with boundaries of reservoirs productive from Upper Pennsylvanian and Lower Permian strata superimposed. Contours in feet. Datum = sea level.

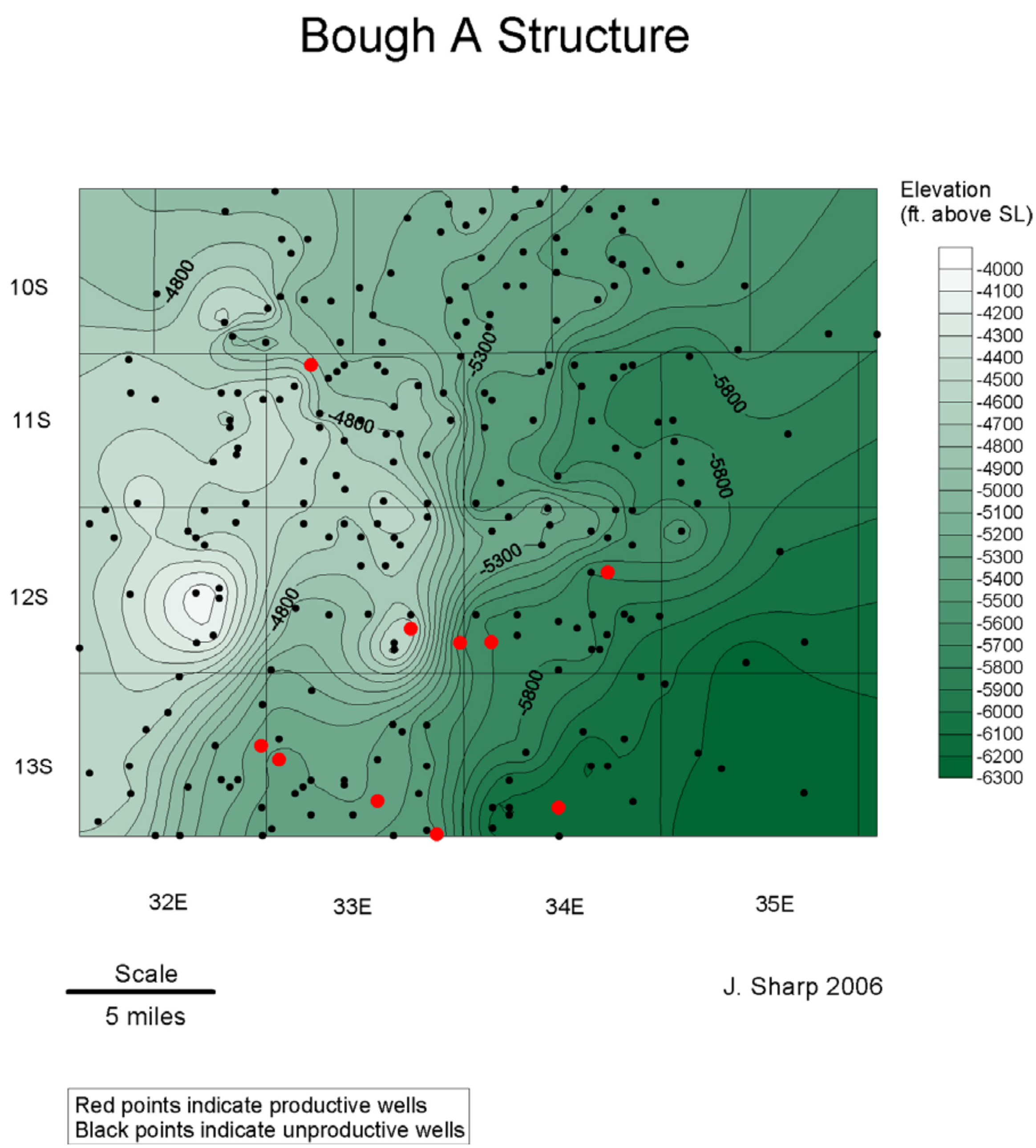


Fig. 3.35. Structure contour map of Bough A member. Dots indicate wells used to construct the map. Red symbols indicate wells productive from the Bough A; black symbols indicate wells that are not productive from the Bough A. Contours in feet. Datum = sea level.

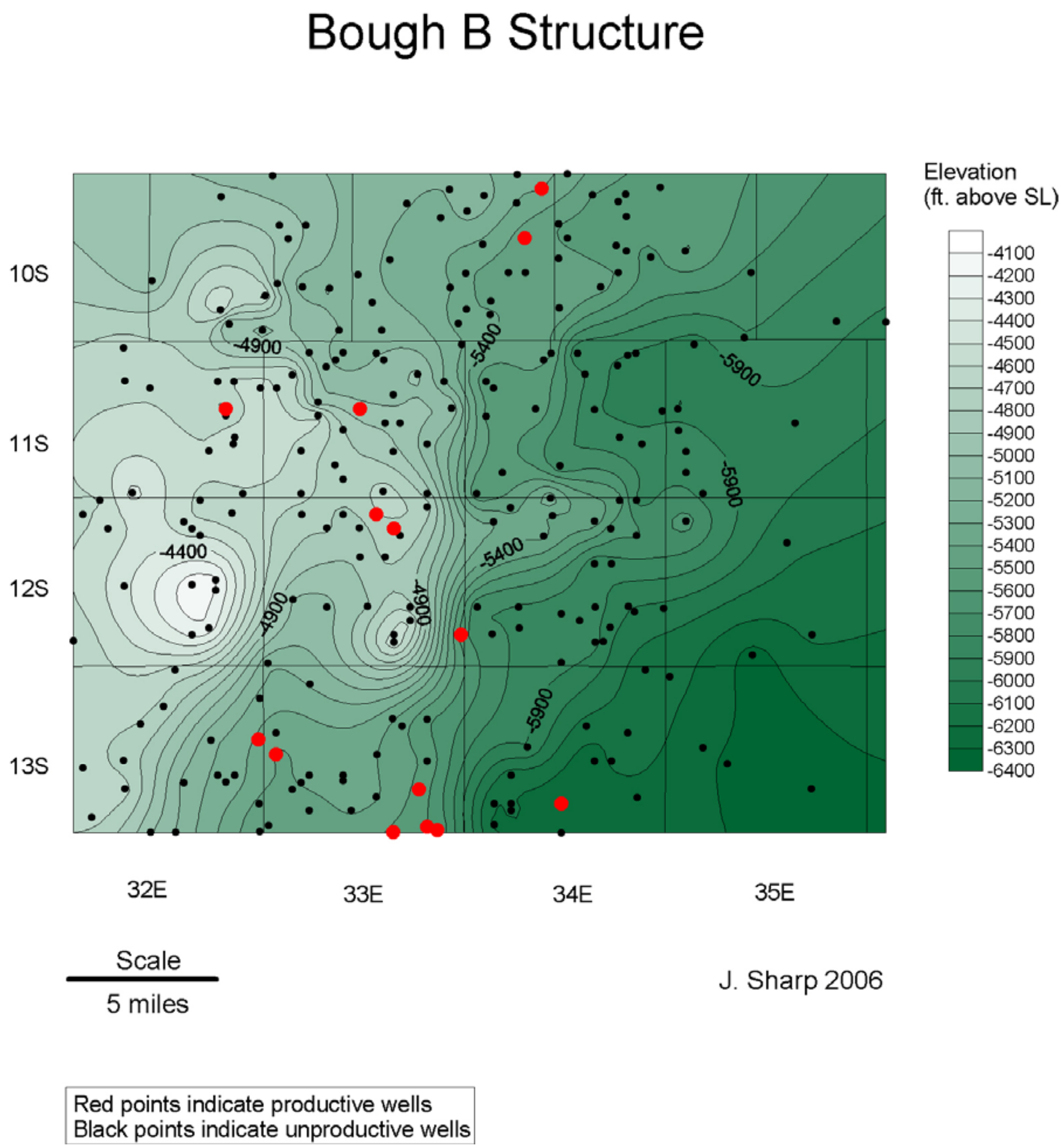


Fig. 3.36. Structure contour map of Bough B member. Dots indicate wells used to construct the map. Red symbols indicate wells productive from the Bough B; black symbols indicate wells that are not productive from the Bough B. Contours in feet. Datum = sea level.

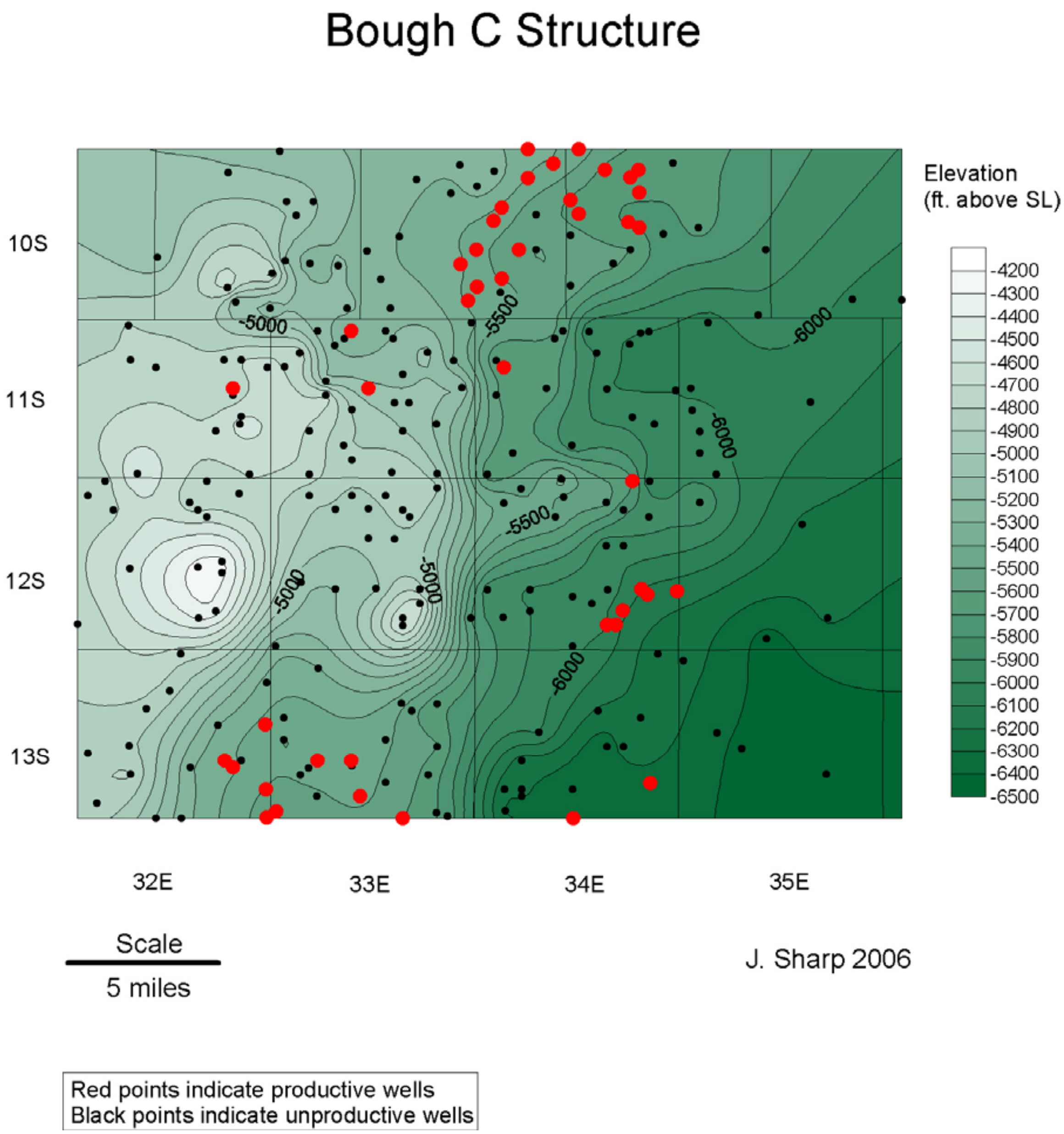


Fig. 3.37. Structure contour map of Bough C member. Dots indicate wells used to construct the map. Red symbols indicate wells productive from the Bough C; black symbols indicate wells that are not productive from the Bough C. Contours in feet. Datum = sea level.

***Paleostructural mapping and analysis*:** This task was mostly completed during 2005 but some additional maps were produced during 2006 from data produced during 2005.

An isopach map of the interval between the top of the Abo Formation (Lower Permian) and the top of the Mississippian System was prepared with *Surfer 8* using the structural data previously acquired (Fig. 3.16). Thin areas denote positive paleostructural elements. Based upon the isopach maps, the axes and directions of plunge of positive paleostructural elements were interpreted and mapped (Fig. 3.17). The Abo-Mississippian isopach map was overlain on a wireframe image (see Fig. 3.38) of Mississippian structure (Fig. 3.39). The resulting map clearly shows an excellent correlation between Mississippian structure and the thickness of the interval between the top of the Abo and the top of Mississippian, indicating major structural movement between the end of Mississippian time and the end of Abo time; where at appropriate relation to sea level, the phylloid algal mounds grew on top of the emerging structures. The Abo-Mississippian isopach map was then overlain on the locations of oil reservoirs that produce from Permo-Penn carbonate strata (Fig. 3.40). As predicted, most, but not all, areas characterized by Permo-Pennsylvanian production coincide with thin areas on the Abo-Mississippian isopach map. Inasmuch as the thin areas represent positive paleostructural elements, it appears that the Abo-Mississippian isopach map, which acts as a proxy for an Ancestral Rocky Mountains paleostructure map, should be a key ingredient for the FEE tool when it comes to predicting the trends and locations of oil reservoirs formed by carbonate stratigraphic traps.

The correlation between paleostructure and the locations of oil reservoirs in Permo-Penn strata is not absolute. Examination of Fig. 3.41 reveals indicated paleostructures that have been proven by drilling to be barren of production. Conversely, there are some productive areas that are not associated firmly with paleostructures. It is believed several factors, principally paleo-water depth over the structures, may be responsible for some structures being barren of production. If the paleostructure caused the bottom of the sea floor to rise up too high then water may have been too shallow to sustain significant algal mound growth in the area above the structure; however, in this case, water may have been sufficiently deep over the flanks of the structure to sustain algal mound growth. If the area over the structure was emergent, then it would have been subject to erosion rather than deposition. On the other hand if water depth was too great, conditions such as nutrient and oxygen supply and the amount of sunlight reaching bottom waters would have been incorrect for the growth of algal mounds and associated reservoirs.

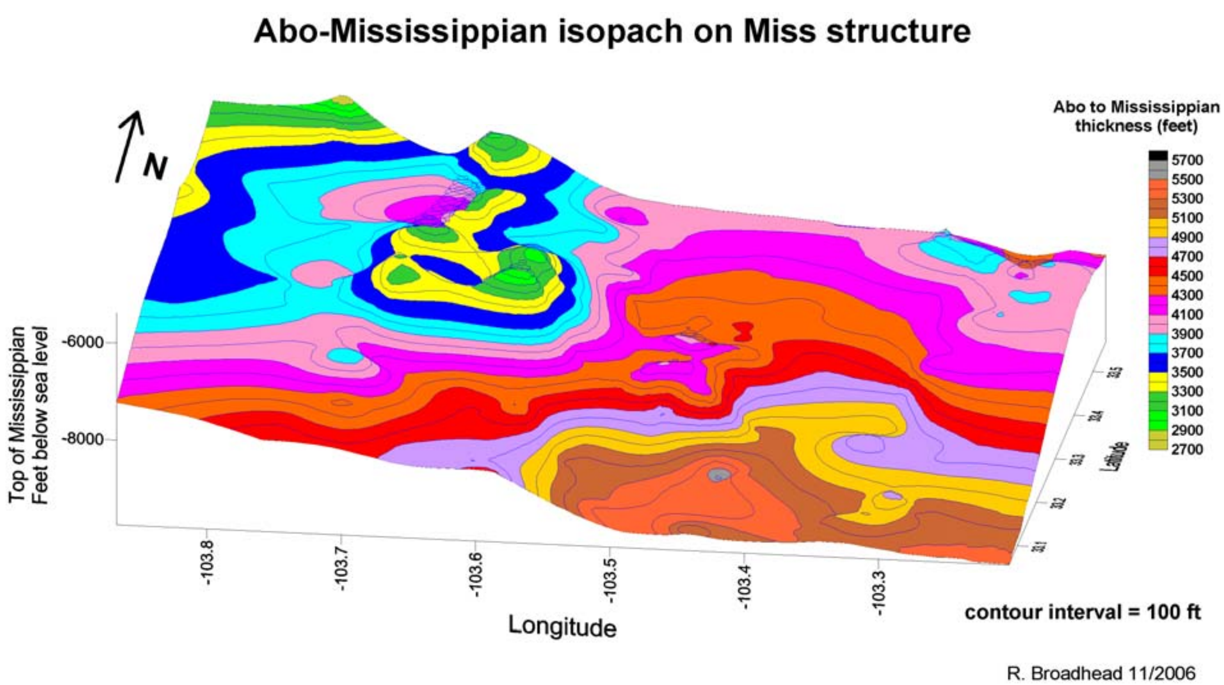


Fig. 3.38. Abo-Mississippian isopach map superimposed on a wireframe relief map of Mississippian structure, Bough intrashelf project area.

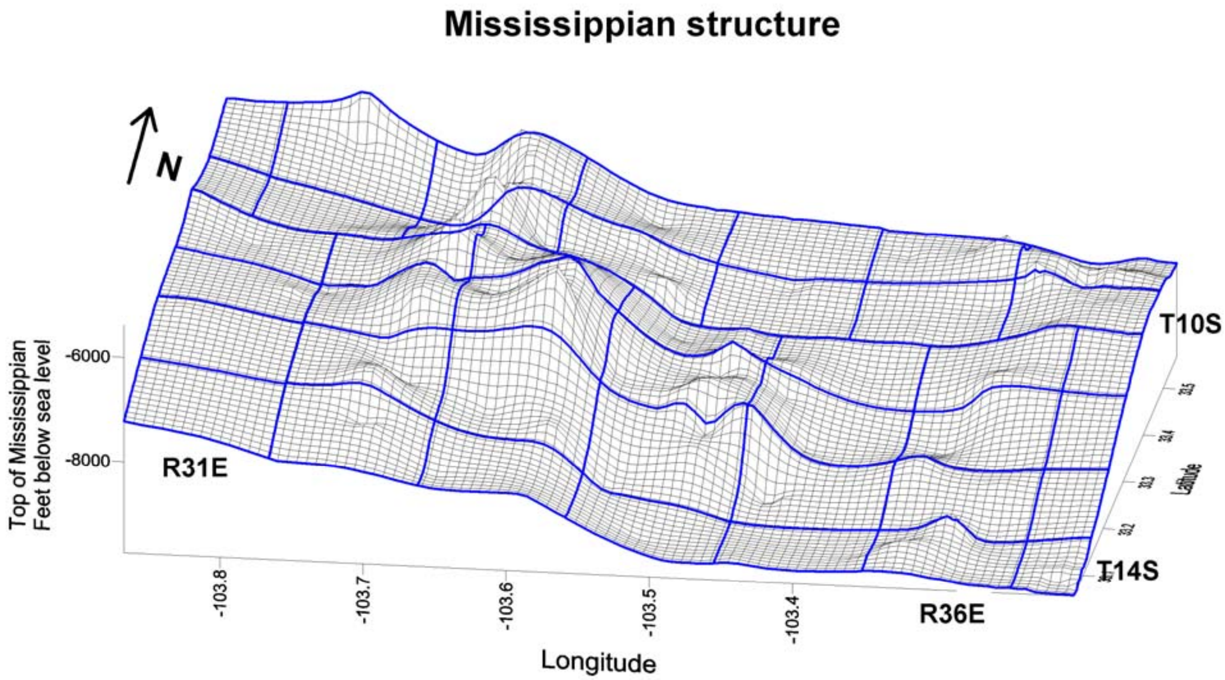


Fig. 3.39. Wireframe relief map of Mississippian structure, Bough intrashelf project area.

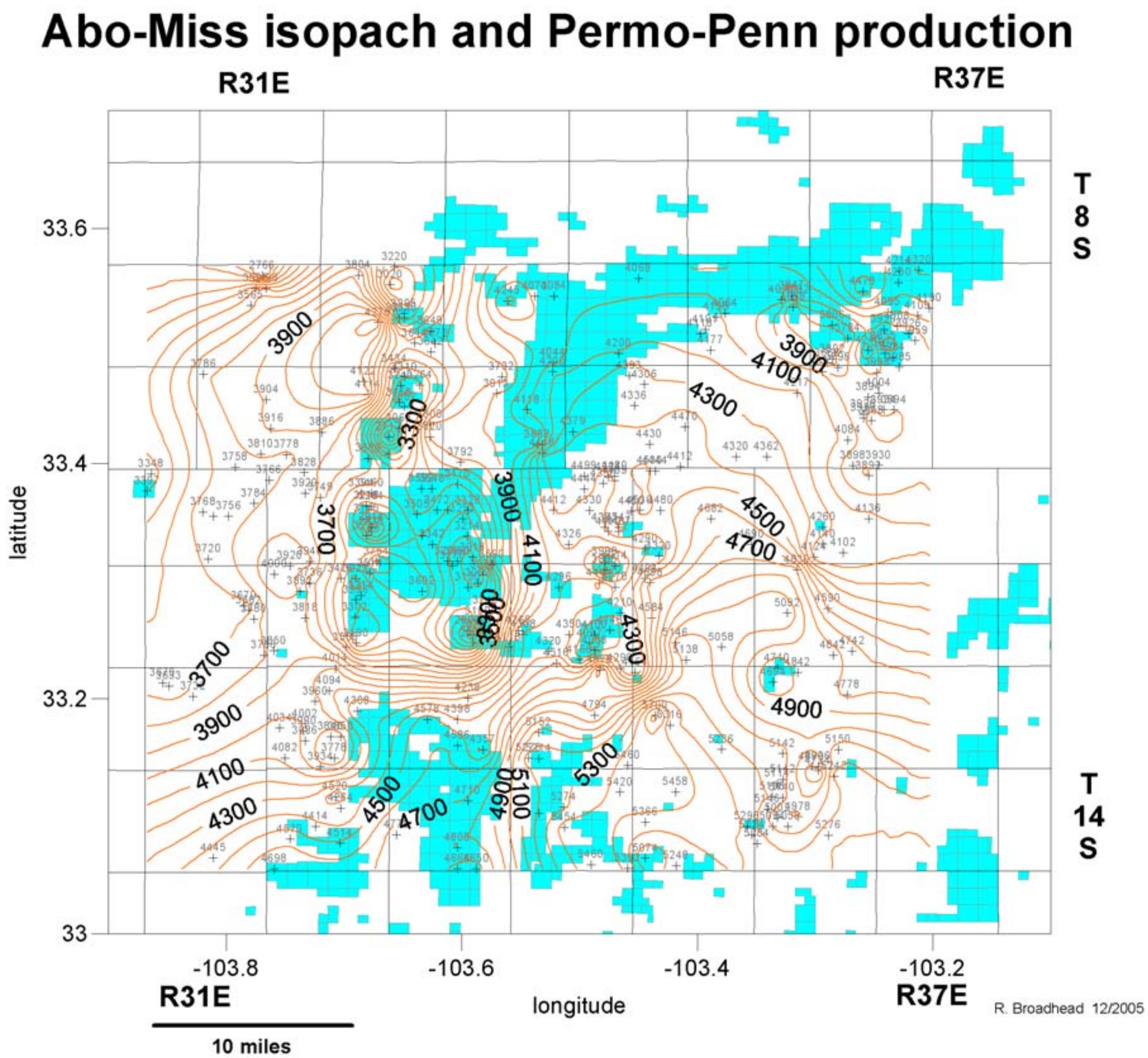


Fig. 3.40. Isopach map of the Abo-Mississippian interval, Bough intrashelf project area with boundaries of reservoirs productive from Upper Pennsylvanian and Lower Permian strata superimposed.

11. ***Reservoir analysis:*** Petrographic analysis of thin sections and acetate peels from two cores in the project area (see Fig. 3.41 for core locations) indicate three petrofacies are present in the Bough: a biomicrite facies, a biosparite facies, and a dolomitized facies.

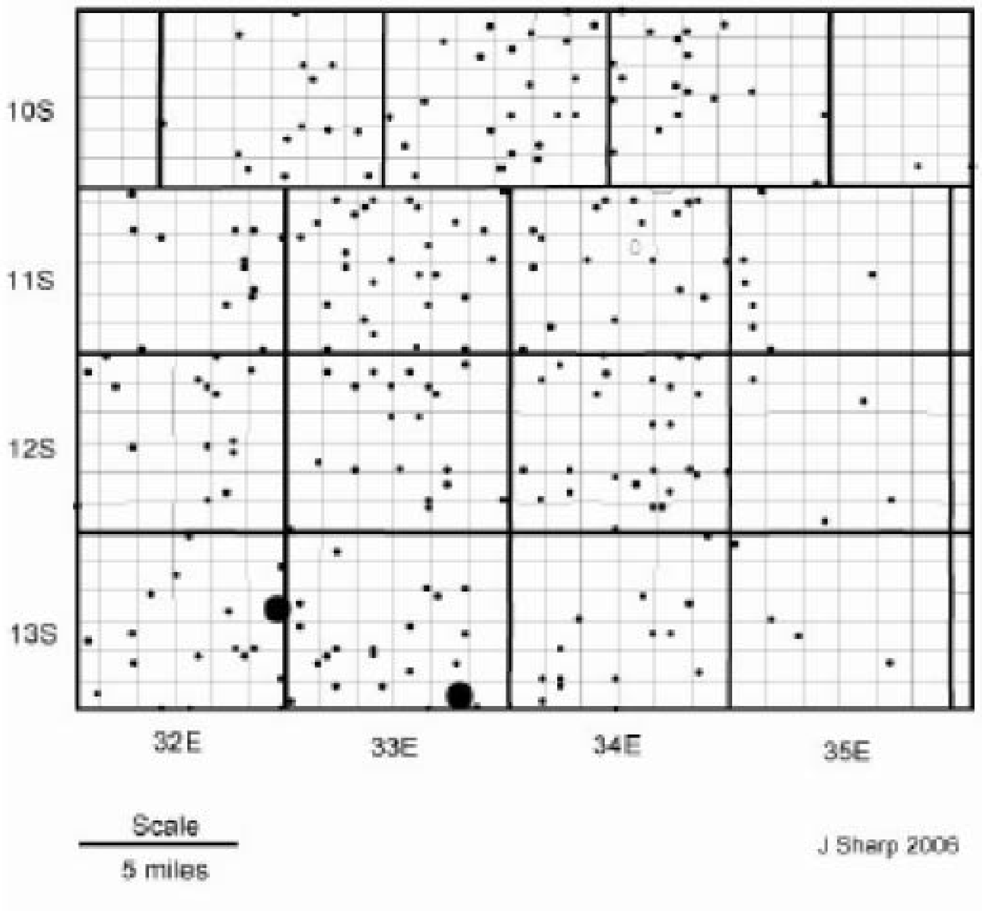


Fig. 3.41. Wells used in mapping and analyzing the detailed study area within the Bough intrashelf project area. Wells with cores are shown as larger symbols.

The *biomicrite facies* (Fig. 3.42) is the main reservoir facies and consists of phylloid algae, echinoderms, brachiopods, fusulinids, bivalves and bryozoans in a micrite matrix. According to the Dunham classification of carbonate rocks, most of the specimens obtained from the biomicrite facies are wackestones; a lesser number of samples are packstones. Porosity is formed mostly by the dissolution of the more mineralogically unstable fossils, especially phylloid algae. Pores are dominantly moldic with a subsidiary amount of solution-enlarged vugs as well as a small amount of fracture and channel porosity. This secondary porosity is preserved where it has not been infilled with sparry calcite cement.

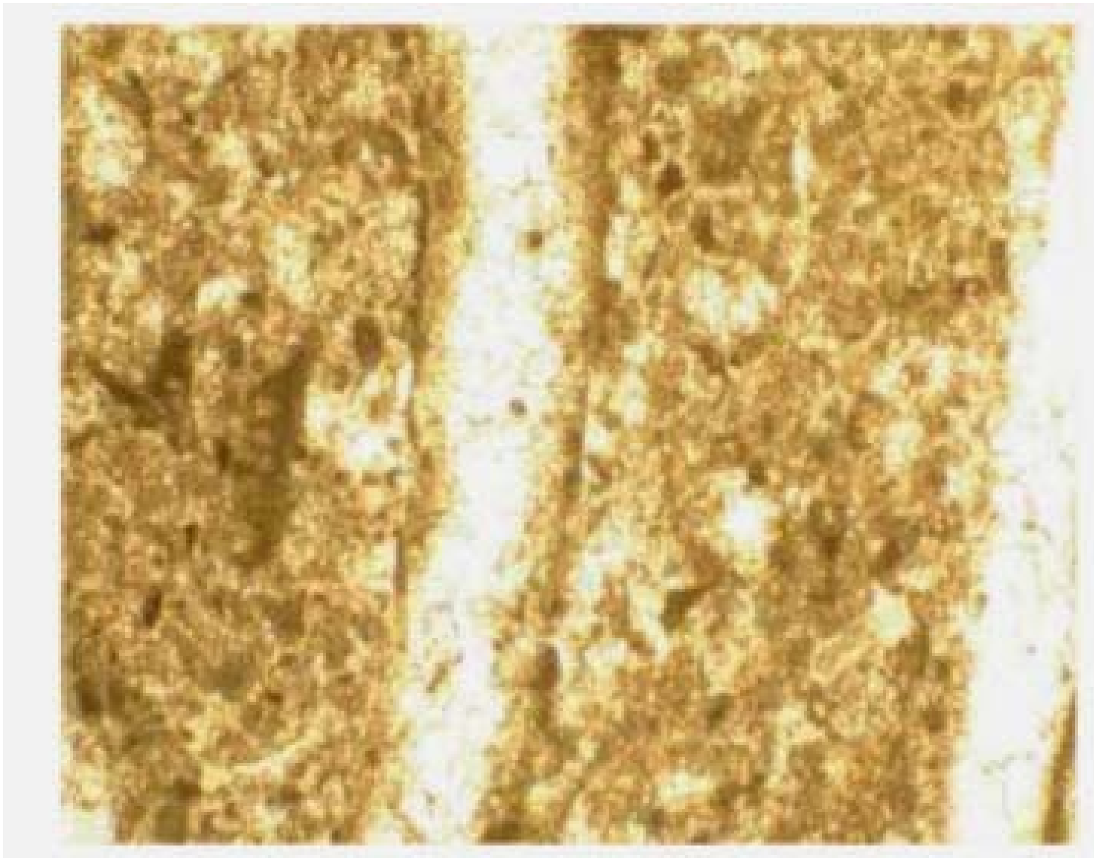


Fig. 3.42. Photomicrograph of biomicrite facies, transmitted light. Darker areas are micrite and lighter areas are calcite cement. Slide is vertically bisected by recrystallized phylloid algal blade with preserved wall structure. Field of view is 1.8 mm. From Sharp (2006).

The *biosparite facies* (Fig. 3.43) consists of phylloid algae, echinoderms, brachiopods, fusulinids, bivalves and bryozoans, but no micrite matrix. The bioclasts float in a sparry matrix. Although some porosity is present within this petrofacies, it is generally much lower than in the biomicrite facies because of occlusion by calcite spar. Porosity, where present, is dominantly moldic. Porosity within this facies attains a maximum value of approximately 30%.

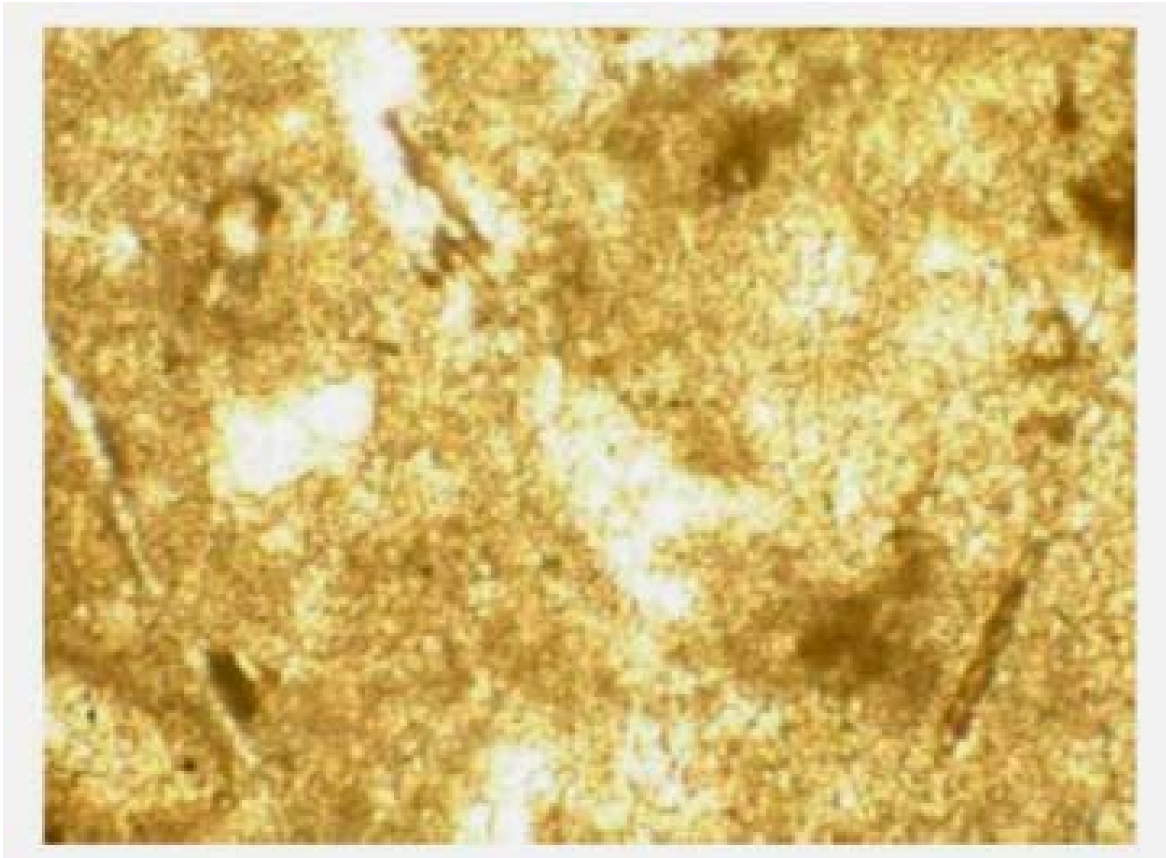


Fig. 3.43. Photomicrograph of biosparite facies, transmitted light. Darker areas are micrite and lighter areas are sparry calcite cement. Recrystallized phylloid algal blade is in center of slide. Field of view is 0.9 mm. From Sharp (2006).

The *dolomitized facies* (Fig. 3.44) is not as common as either the biomicrite facies or the biosparite facies. The dolomitization in this facies has obliterated depositional textures. It consists mostly of microcrystalline planar-e dolomite matrix; minor spherical crystals of dolomite are contained in the matrix. It is thought that these larger spheres nay be either relict ooids or burrows. Some microcrystalline calcite is present within samples from this facies. Porosity within this facies is intercrystalline and has a maximum value of approximately 20%.

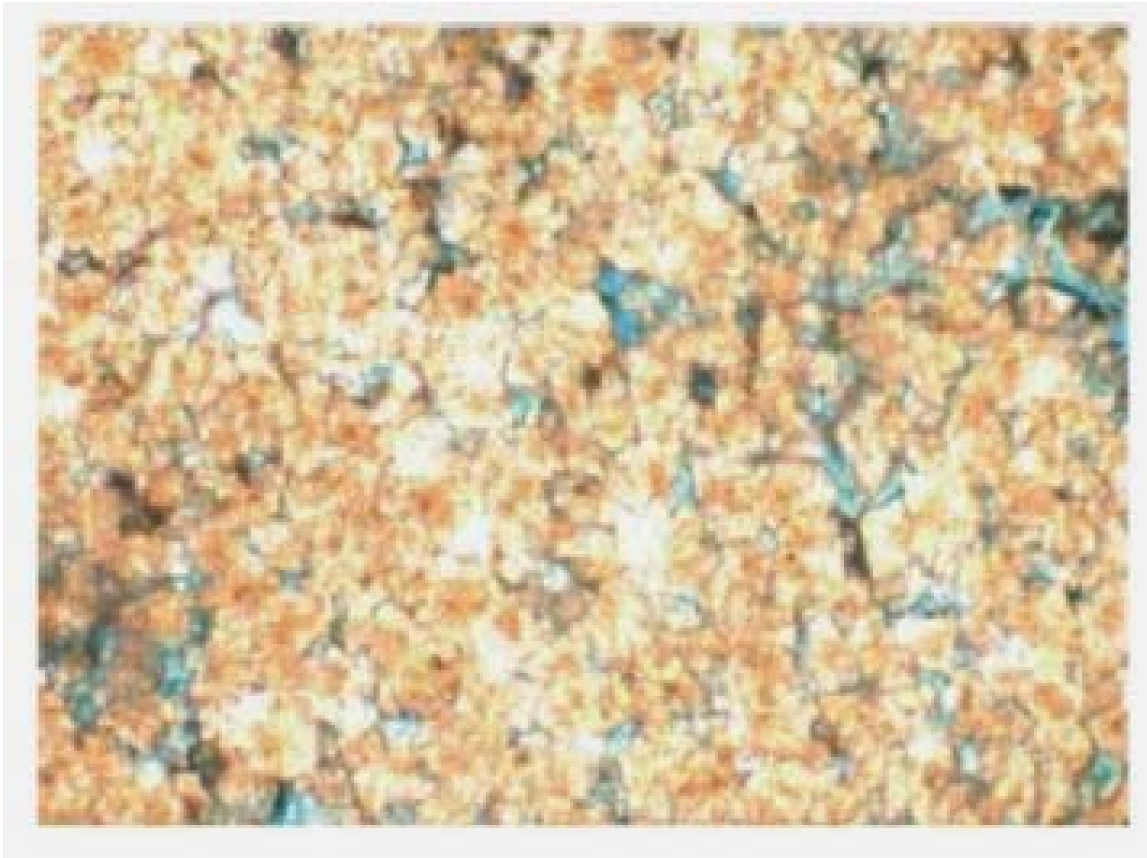


Fig. 3.44. Photomicrograph of dolomitized facies, transmitted light. Lighter areas are subhedral dolomite crystals and darker areas are crystal faces. The blue areas are intercrystalline pores filled with blue epoxy. Field of view is 0.9 mm. From Sharp (2006).

Porosity within the Bough carbonate reservoirs is secondary. The main porosity type present is moldic, although solution-enlarged vugs, channel and fracture porosity are also present. Reservoir development is diagenetic and is related to dissolution of primary components. In some cases, a relatively late-stage cement has acted to occlude this secondary porosity.

Dagger Draw North Shelf-Margin Project Area

Introduction

Geologic investigation into a second project area was initiated during 2006. This area, referred to as the *shelf-margin project area* (Fig. 3.2), is located at the margin of the Late Pennsylvanian shelf where Upper Pennsylvanian phylloid algal mound reservoirs similar to those described above in the Bough area are prolifically productive of oil and associated natural gas. However, this project area was chosen because there are distinct differences between it and the Bough area. In the Bough area, the phylloid algal mound complexes grew on Late Pennsylvanian paleostructures present on the Northwest Shelf of the Permian Basin. In the shelf-margin project area, however, the phylloid algal mound complexes that form the oil reservoirs grew on a constructional shelf margin that separated the Northwest Shelf (on the northwest) from the deep Delaware Basin (to the southeast; see Cox et al., 1998; Speer, 1993). As will be discussed below, the difference in depositional setting of the phylloid algal mounds in each project area (growth on top of existing paleostructures in the Bough area vs. constructional shelf-margin buildup in the shelf-edge Dagger Draw area) mandates that different geological procedures and thought processes need to be used for exploration in each of the two types of areas, despite the similar biologic and genetic origins for the phylloid algal mound reservoirs in each area. Whereas it is relatively straightforward to map paleostructures in the Bough area, a lack of correlatable marker beds at the Abo level and perhaps a lack of paleostructures indicate that paleostructures cannot be mapped in the shelf-margin area. Instead, geologic procedures used to identify paleobathymetric relief, rather than paleostructural relief, must be employed to identify and delineate productive fairways,

During the 2006 project year, work began and was completed on collecting data, correlating relevant stratigraphic units, identifying productive trends, and producing appropriate computer-generated maps. As with the Bough intrashelf area, geologic contour maps were produced with *Surfer 8* (a product of Golden Software, Inc.). Geologic and well data obtained during the 2006 project year are presented in the Excel spreadsheet ***shelf margin area.xls*** (attached in Appendix II).

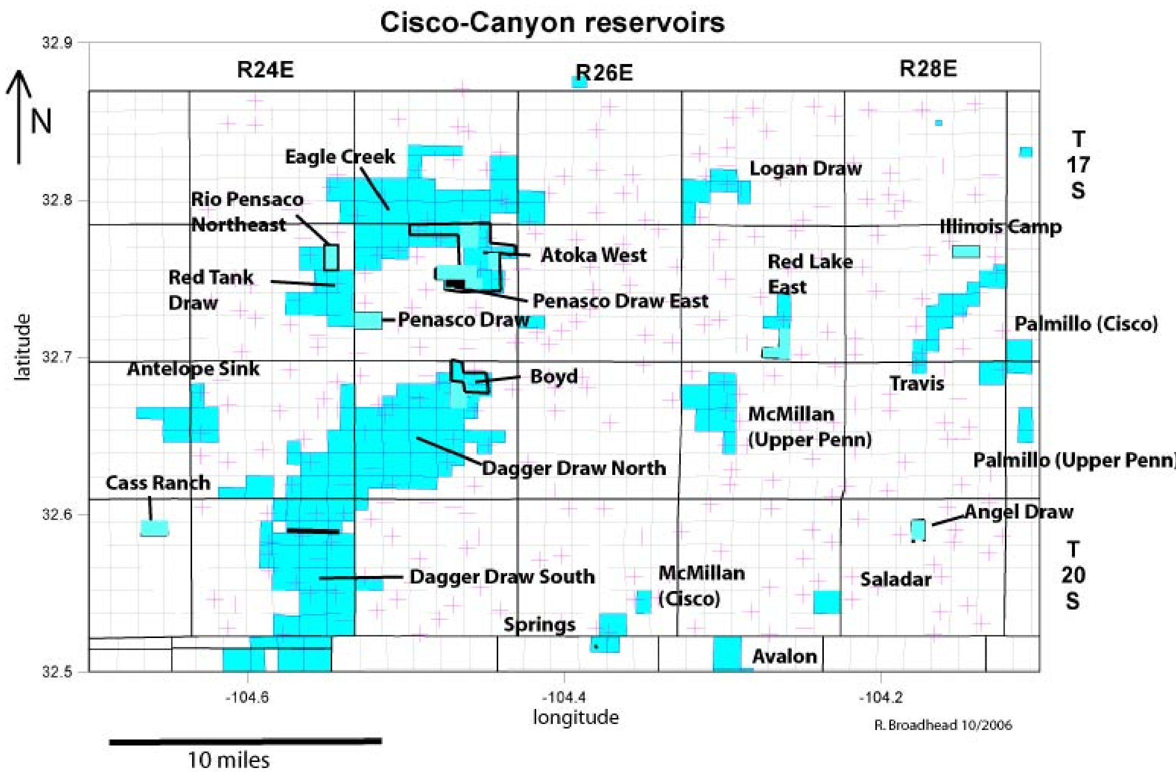


Fig. 3.45. Oil and gas reservoirs that are productive principally from Upper Pennsylvanian strata within the shelf-margin project area. See Table 3.3 for reservoir data**.**

Twenty-four oil and gas reservoirs are productive from Upper Pennsylvanian strata within the shelf-margin project area (Fig. 3.45, Table 3.3). These reservoirs had produced, cumulatively, 83 million bbls oil and 492 billion ft^3 gas at the end of 2003. During 2003, production from the 24 reservoirs was 667 thousand bbls oil and 12 billion ft^3 natural gas. The largest reservoirs are Dagger Draw North and Dagger Draw South, which have produced a combined cumulative of 78.5 million bbls oil, or 95% of the cumulative production for all 24 reservoirs. Dagger Draw North and Dagger Draw South have also produced a combined cumulative of 389 billion ft^3 gas, or 79% of the cumulative production for all 24 reservoirs. The 24 reservoirs contained a combined total of 504 oil and gas wells during 2003. Depth to production ranges from 6150 ft at Antelope Sink to 10020 ft at Angel Draw and Saladar.

Table 3.3. Permo-Pennsylvanian Carbonate Reservoirs Productive within the Shelf Margin Project Area (See Fig. 3.45 for Locations of Reservoirs)

Reservoir name	**Productive stratigraphic unit**	**Annual oil production 2003 (thousand bbls)**	**Cumulative oil production 2003 (million bbls)**
Angel Draw	(Upper Pennsylvanian)	5	0.005
Antelope Sink	(Upper Pennsylvanian)	0.5	0.024
Atoka West	(Upper Pennsylvanian)	0.4	0.006
Avalon	(Upper Pennsylvanian)	0.1	0.015
Boyd	(Cisco)	0	0.001
Cass Ranch	(Upper Pennsylvanian)	0	0
Dagger Draw North	(Upper Pennsylvanian)	476	53.8
Dagger Draw South	(Upper Pennsylvanian)	124	24.7
Eagle Creek	(Permo-Pennsylvanian)	3	0.1
Illinois Camp	(Cisco)	0	0.0005
Logan Draw	(Cisco-Canyon)	0.01	0.03
McMillan	(Cisco)	0	0
McMillan	(Upper Pennsylvanian)	1	0.425
Palmillo	(Cisco)	0	0.001
Palmillo	(Upper Pennsylvanian)	0	0.03
Penasco Draw	(Upper Pennsylvanian)	10	0.5
Penasco Draw	(Permo-Pennsylvanian)	1	0.04
Penasco Draw East	(Upper Pennsylvanian)	9	0.03
Red Lake East	(Upper Pennsylvanian)	0	0.14816
Red Tank Draw	(Permo-Pennsylvanian)	0.03	0.0002
Rio Penasco Northeast	(Upper Pennsylvanian)	0	0
Saladar	(Upper Pennsylvanian)	0	0.001
Springs	(Upper Pennsylvanian)	3	0.7
Travis	(Upper Pennsylvanian)	34	2.1

The importance of the reservoirs within the Dagger Draw area cannot be overstated from either a production standpoint or from an exploration standpoint. The Dagger Draw reservoirs were discovered in 1964, but remained sparsely drilled and underdeveloped until 1990 as the reservoir and trapping mechanism were incompletely understood. In the late 1980's, however, additional exploration and development revealed that this seemingly small oil field was substantially larger than had originally been thought. As exploration and development revealed the true nature of the reservoir and trap, production from the field increased from a few thousand bbls oil per year to almost 10 million bbls oil per year (Fig. 3.46; Broadhead, 1999a). This phase of redevelopment led to exploitation of the full reservoir (Fig. 3.47) and what had been viewed as a small and relatively insignificant oil field became a major productive area that contributed slightly more than 13% of all oil production in New Mexico during 1996.

Reservoirs are mostly productive from Canyon strata, although some are productive from the Cisco (see Fig. 3.3). In Table 3.3, most reservoirs identified as being productive from the Upper Pennsylvanian have the Canyon as the primary productive interval. Reservoirs identified as Permo-Pennsylvanian are productive from uppermost Pennsylvanian strata and in some cases lowermost Permian strata as well. As discussed above, reservoirs are productive from complexes of phylloid algal mud mounds. The primary reservoirs in the project area, Dagger Draw North and Dagger Draw South, are formed by complexes of phylloid algal mounds that were located on the Late Pennsylvanian shelf margin (Fig. 3.48). The reservoirs strata have been dolomitized. Porosity is vugular (Speer, 1993; Cox et al., 1998). Updip seals are formed by impervious back-reef limestones (Fig. 3.49). Dark basinal shales that are adjacent to and interfinger with the dolostone reservoirs on the east (basinward) side are the apparent source rocks.

Exploration methodology for the Dagger Draw and Bough areas will differ because of the contrasting geologic setting of the phylloid algal mound reservoirs in each area. In the Bough area, the phylloid algal mounds grew on emerging Pennsylvanian-age structures on the interior of a shallow-marine shelf. The emerging structures localized growth of the phylloid algal mounds. Therefore, Bough reservoirs are directly related to paleostructures and off-structure areas generally are barren of reservoirs, as described previously. Mapping of paleostructures will therefore be of primary importance in exploration.

In the Dagger Draw shelf-margin area, however, growth of phylloid algal mounds was primarily localized by paleobathymetric position on the shelf edge, which was constructional rather than structural in origin. Therefore, paleostructure mapping will not be helpful in the location of (exploring for) reservoirs, and other geologic techniques need to be employed.

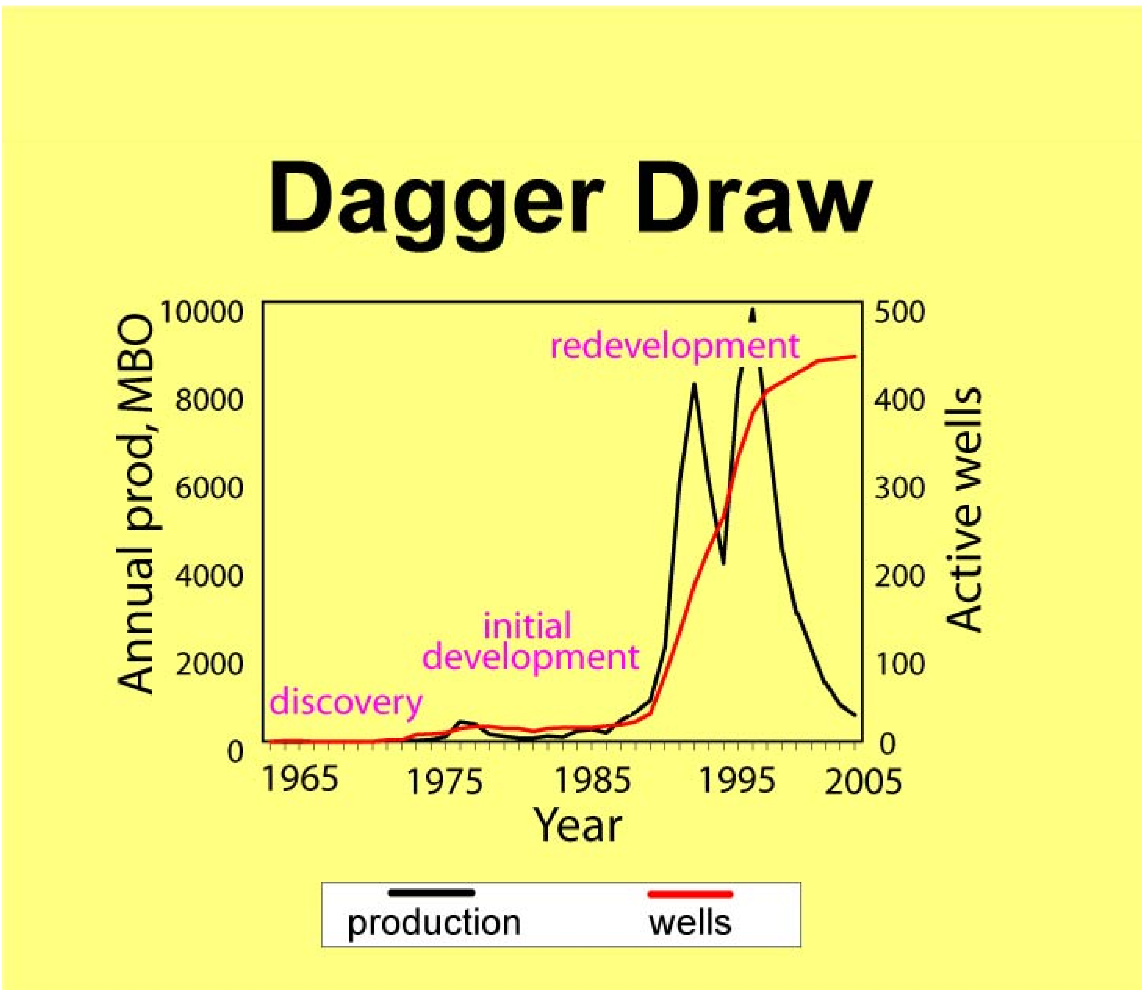


Fig. 3.46. Production history curve of the Dagger Draw reservoirs, showing periods of discovery and initial development of a seemingly small reservoir, and final full redevelopment that revealed the true size of this very large oil reservoir. After Broadhead (1999a).

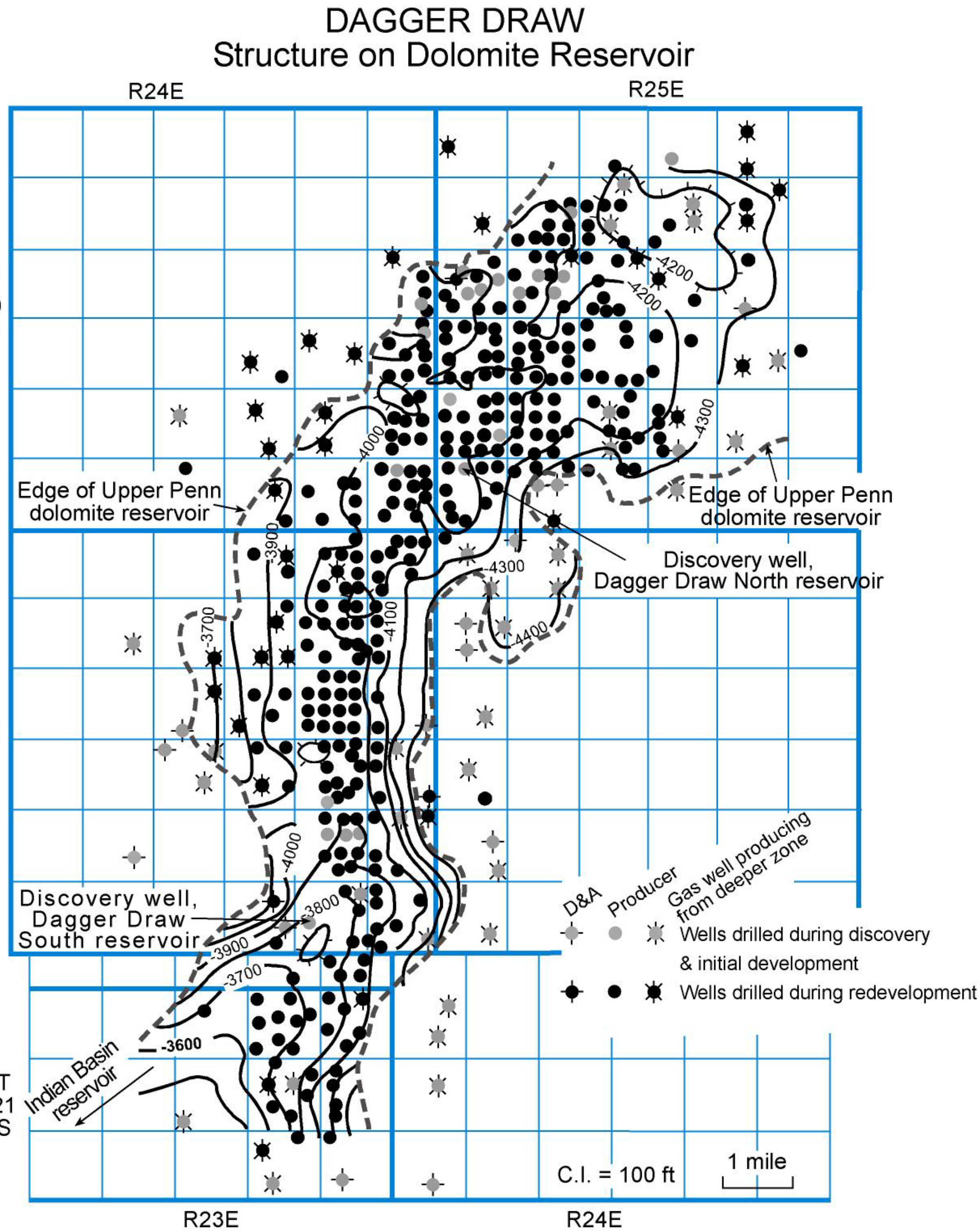


Fig. 3.47. Structure contour map on top of productive dolostone shelf-margin carbonate buildup facies, Dagger Draw and Dagger Draw South reservoirs indicating wells drilled during phases of (1) discovery and initial development, and (2) redevelopment. Structure contours from Reddy (1995).

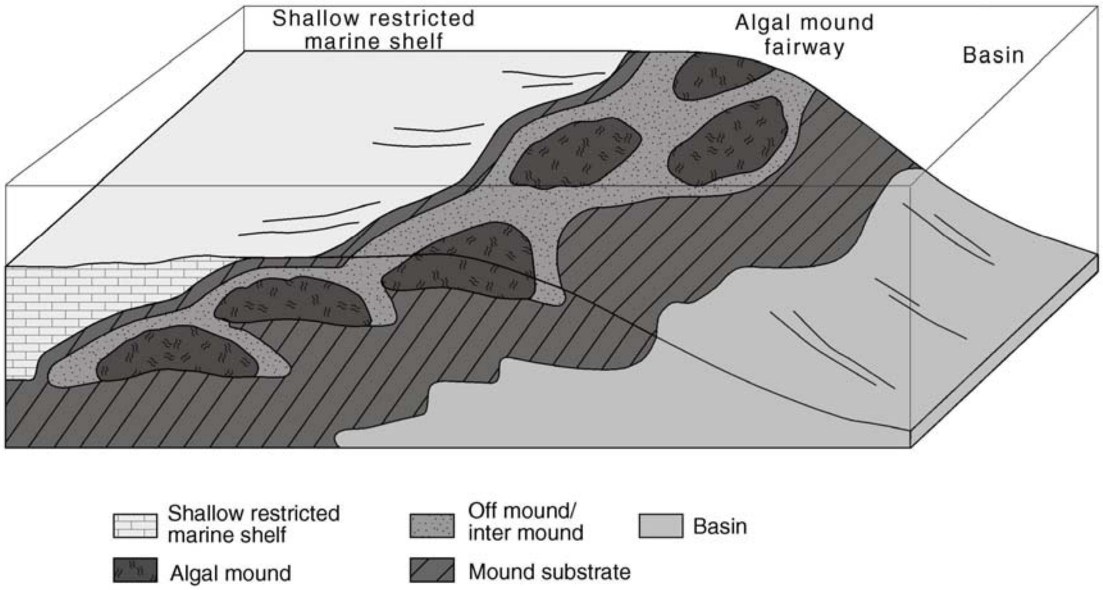


Fig. 3.48. Depositional model of shelf-margin phylloid algal mounds and intramound facies at shelf margin, Dagger Draw reservoirs. From Cox et al. (1998).

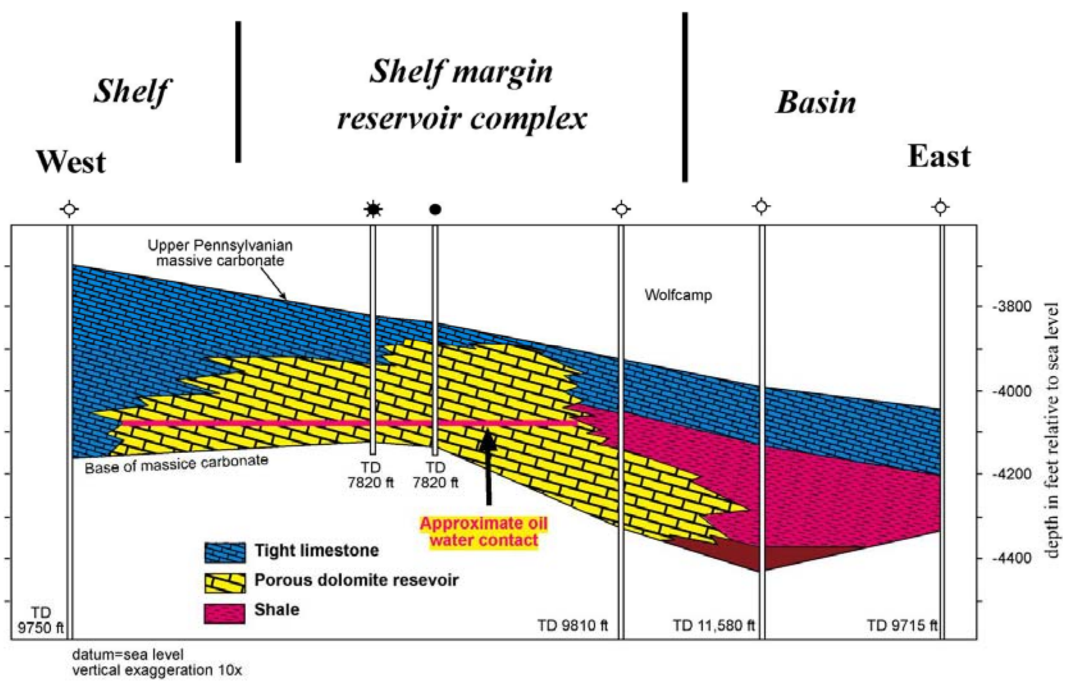


Fig. 3.49. West-east structural cross section though Upper Pennsylvanian strata in Dagger Draw South reservoir showing morphology of dolomitized shelf-margin reservoir facies, impermeable backreef limestones, and basinal shales. From Speer (1993).

Data Acquisition and Mapping

During 2006, 312 wells were mapped and correlated within the shelf margin project area (Fig. 3.50). Because the area straddles the boundary between the shallow Northwest Shelf and the deep Delaware Basin, few stratigraphic units are directly correlatable from shelf to basin. On the shelf (Fig. 3.51), the shelfal Abo carbonates directly overlie the Wolfcamp carbonates whereas in the basin (Fig. 3.52), the basinal Bone Spring Formation directly overlies the Wolfcamp section. Within the Dagger Draw reservoir along the shelf margin, the well logs reflect yet a different lithologic facies of the shelf-edge phylloid algal mound complexes (Fig. 3.53). Therefore, unlike in the Bough area, the Abo, which is not present in the basin, cannot be mapped across the entire project area and is therefore of limited use for either structure mapping or for stratigraphic mapping. Even the top of the Cisco Series and the Canyon Series cannot be reliably correlated across the entire project area (although they can be correlated reliably within the Dagger Draw North and Dagger Draw South reservoirs, see Reddy, 1995) and different operators make grossly different picks for the tops of these units. One lithologic unit that can apparently be correlated across the entire project area is a prominent shale (called the upper Wolfcamp shale in this report) in the upper part of the Wolfcamp. This unit, along with the top of the Mississippian Series, was correlated in all 312 wells.

A structure contour map on top of the Mississippian (Fig. 3.54) reveals no discrete break between the Northwest Shelf and the Delaware Basin. Instead, the transition from the shelf to the basin is marked by a uniform slope at the Mississippian level. Only perhaps a few subtle local structures are superimposed on the regional southeast slope.

A structure contour map on top of the upper Wolfcamp shale (Fig. 3.55) indicates a sharp break between the Northwest Shelf and the Delaware Basin at the Wolfcamp level. Because this transition from shelf to basin is evident at the upper Wolfcamp shale level but not at the deeper Mississippian level, it was concluded that the relief indicated on the upper Wolfcamp shale structure map (Fig. 3.55) is constructional rather than structural in origin. Furthermore, an isopach map of the stratigraphic interval between the top of the upper Wolfcamp shale and the top of the Mississippian (Fig. 3.56) does not reveal a thinning over the shelf margin as the Abo-Mississippian isopach map revealed a thinning over paleostructures in the Bough area, but instead reveals a thickening at the shelf margin. This map apparently reflects drape of the Wolfcamp shale over the thickened Upper Pennsylvanian shelf-margin carbonate complex that grew at the constructional shelf edge. As such, this isopach map, as well as the structure map of the upper Wolfcamp shale (Fig. 3.58) reveals the location of principal areas of growth of the Upper Pennsylvanian phylloid algal mounds at the shelf margin.

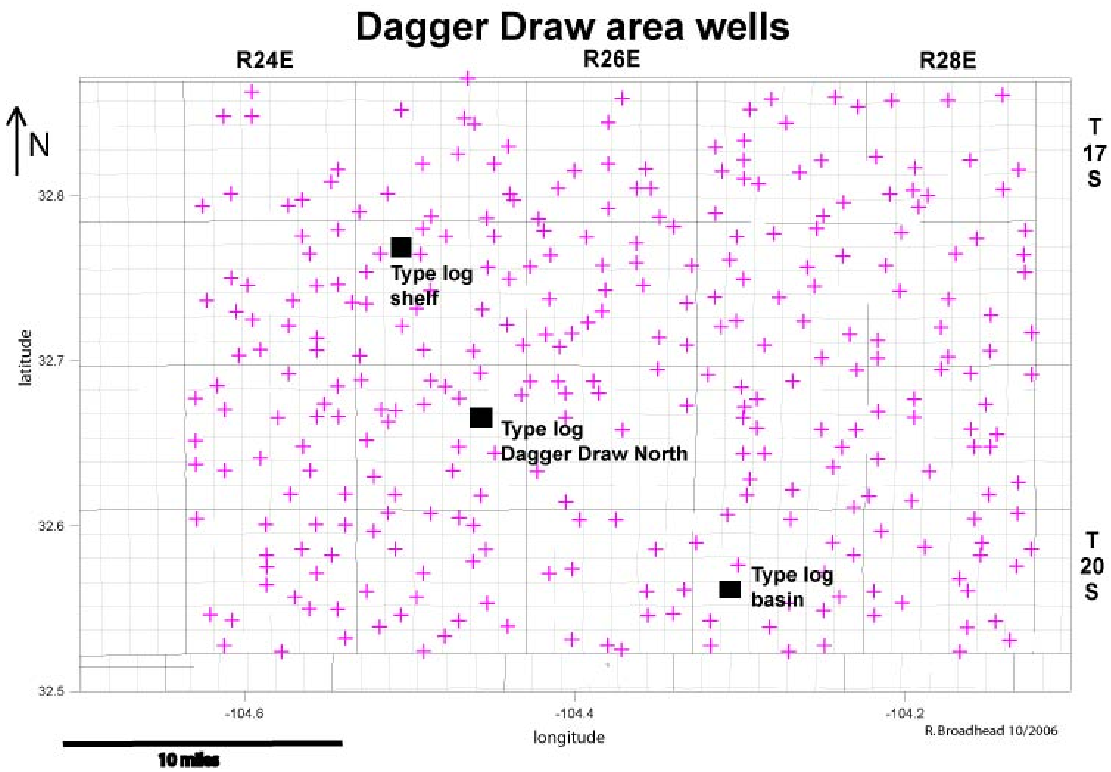


Fig. 3.50. Locations of wells analyzed for this project in the shelf-margin project area and locations of type logs for the shelf area, basin area and Dagger Draw North reservoir (Figs. 3.51–3.52).

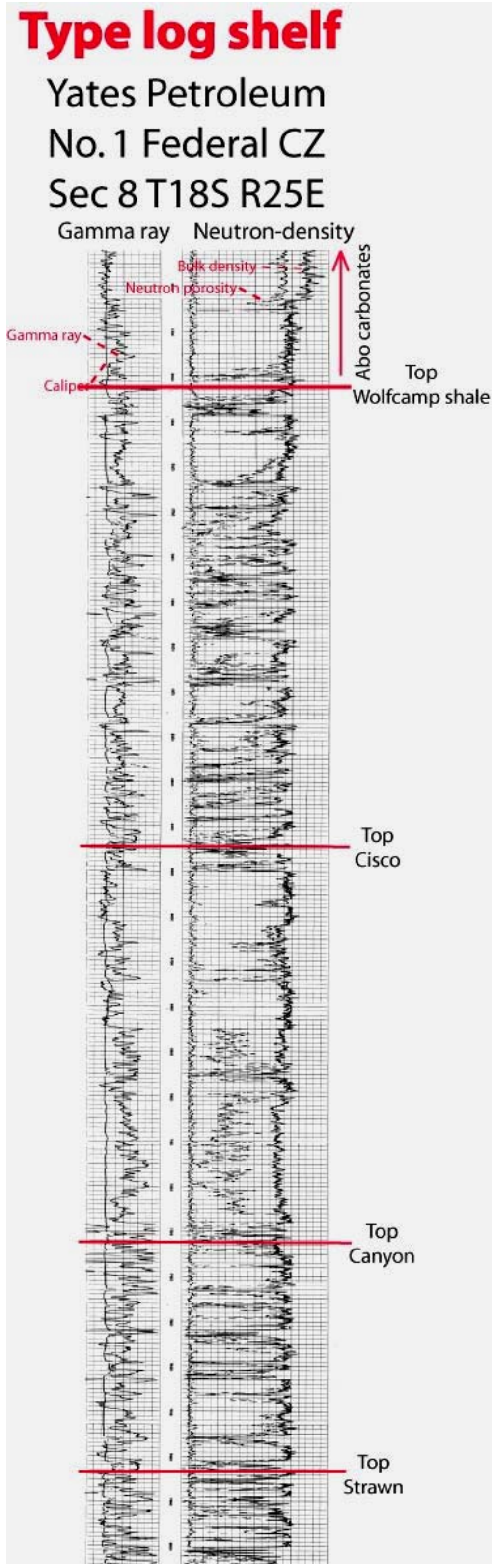


Fig. 3.51. Type log through Upper Pennsylvanian shelf facies. See Fig. 3.50 for location.

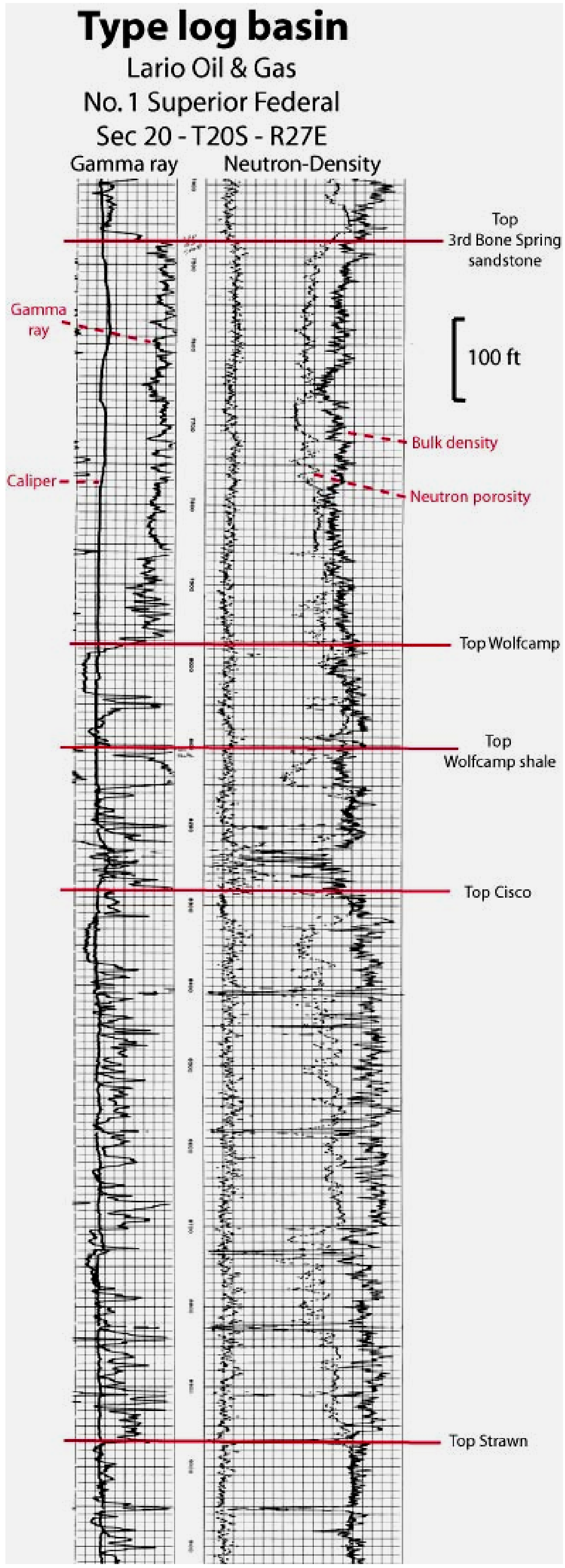


Fig. 3.52. Type log through Upper Pennsylvanian basinal facies. See Fig. 3.50 for location.

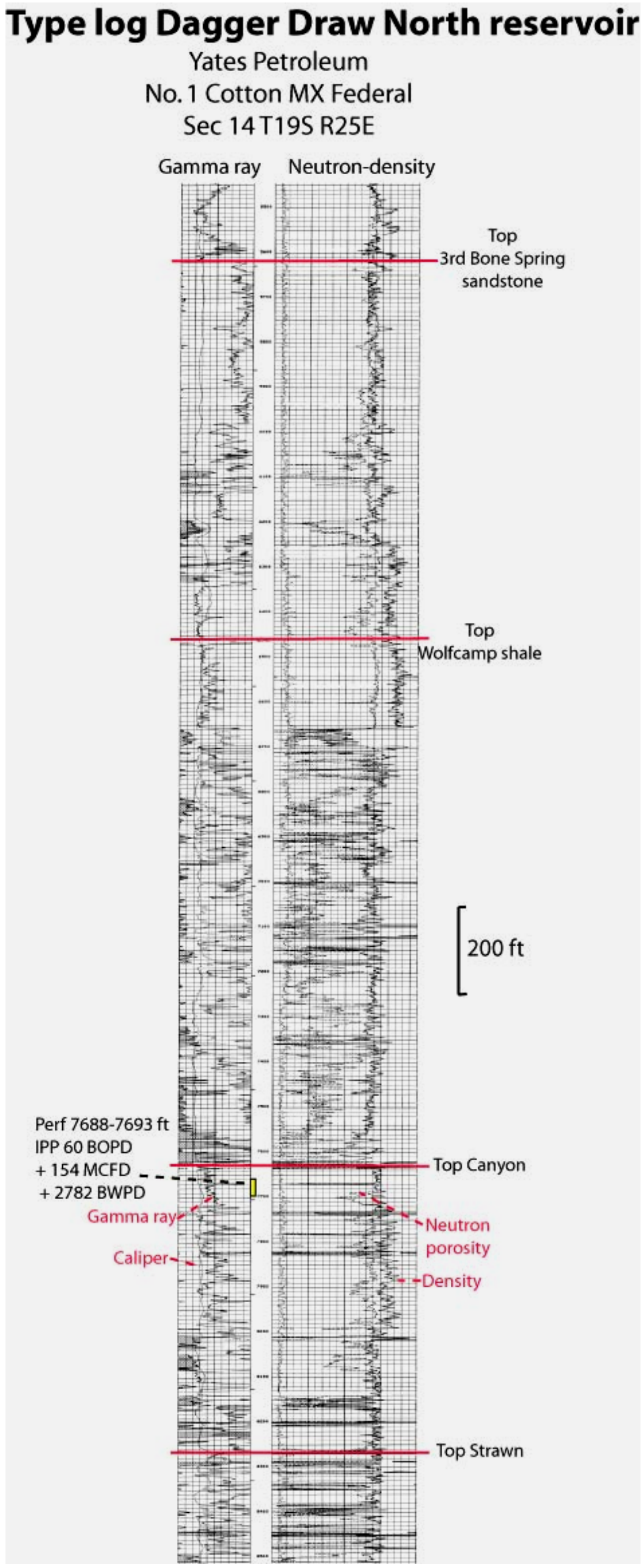


Fig. 3.53. Type log through Upper Pennsylvanian shelf-margin facies, Dagger Draw North reservoir, indicating productive zone. See Fig. 3.50 for location.

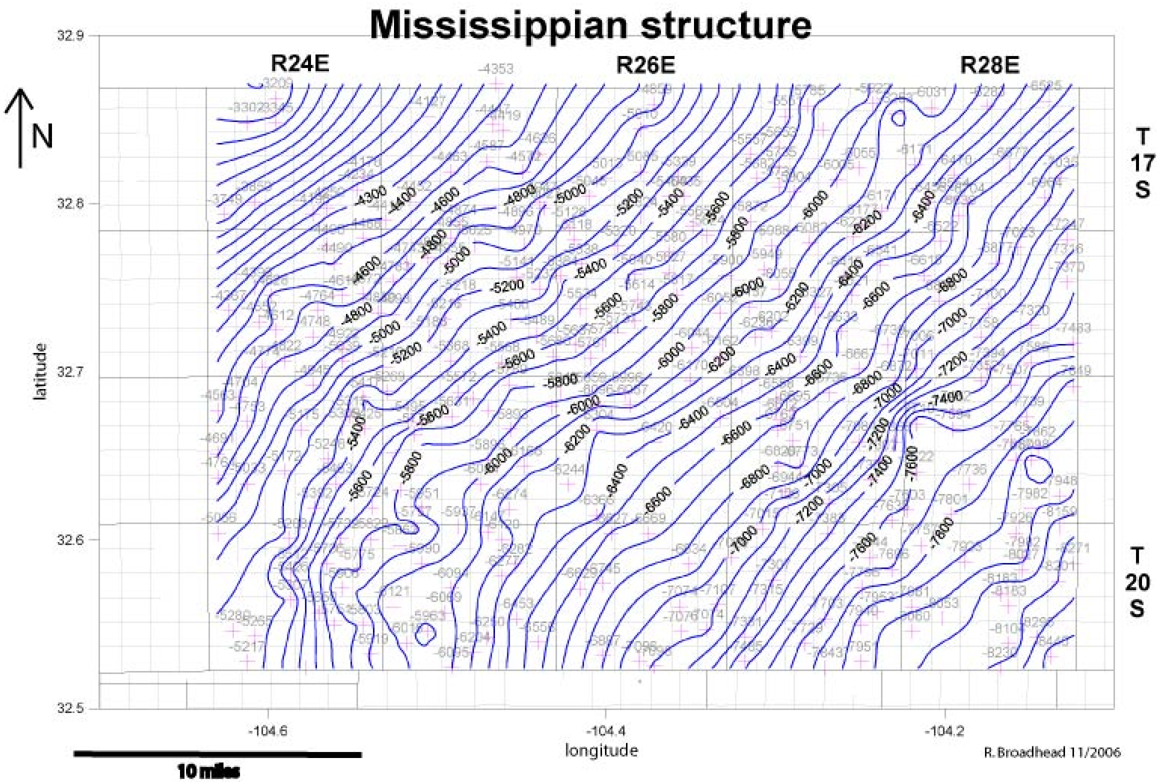


Fig. 3.54. Structure contours on top of Mississippian strata, shelf-margin project area. Contours in feet. Datum = sea level.

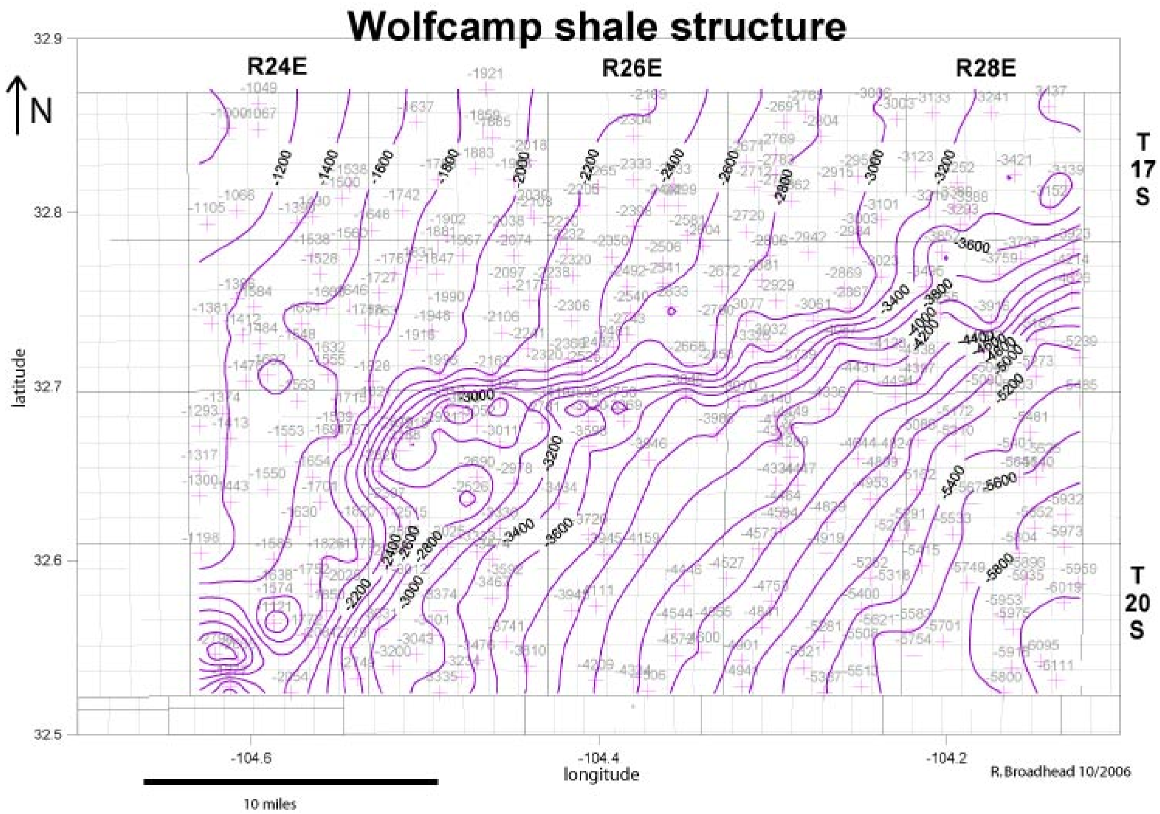


Fig. 3.55. Structure contours on top of upper Wolfcamp shale, shelf-margin project area. Contours in feet. Datum = sea level.

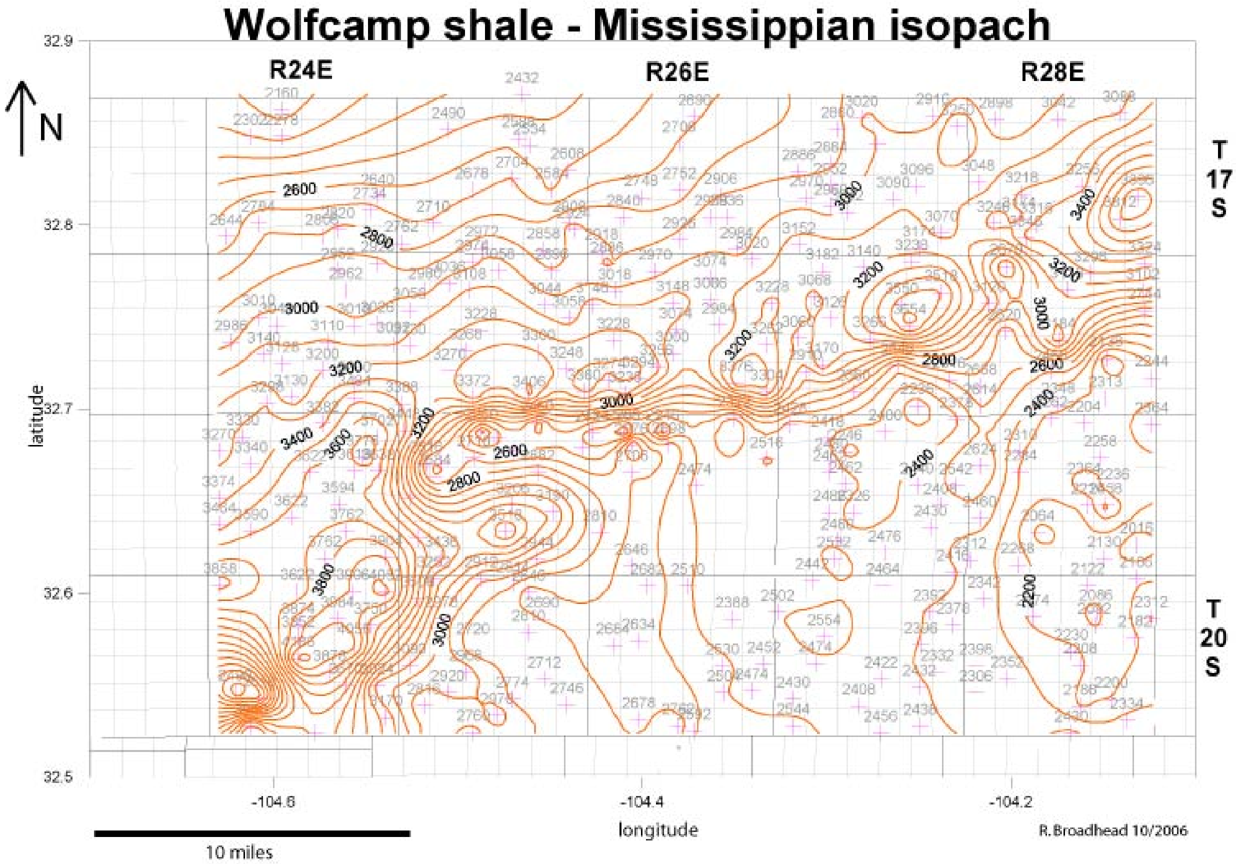


Fig. 3.56. Isopach map of stratigraphic interval between the top of the upper Wolfcamp shale marker and the top of the Mississippian System, shelf-margin project area.

Relationship of Geology to Oil and Gas Reservoirs

Superposition of the map of the Cisco and Canyon reservoirs on the Mississippian structure (Fig. 3.57) reveals no obvious correlation between the location of reservoirs and the structure. Although the larger reservoirs form elongate trends that parallel the Mississippian structure contours, there is no apparent distinction among contours that can be used as a predictive tool to determine which of the Mississippian contours might be parallel to the reservoir trends in the overlying Upper Pennsylvanian strata. However, when the map of Cisco and Canyon reservoirs are superimposed on the structure contour map of the upper Wolfcamp shale (Fig. 3.58) as well as the isopach map of the interval between the top of the Wolfcamp Shale and the top of the Mississippian System (Fig.

3.59), an obvious correlation between the location of known productive reservoirs and structure emerges. Of course, as discussed above, the Wolfcamp shale structure is not tectonic, but instead reflects drape of the upper Wolfcamp shale over the shelf-margin carbonate complex. The primary Canyon reservoirs, Dagger Draw North and Dagger Draw South, are located along the shelf edge in the southwest part of the map. Other smaller reservoirs, Travis and Red Lake East, lie along this trend of closely spaced contours to the northeast of Dagger Draw North and Dagger Draw South.

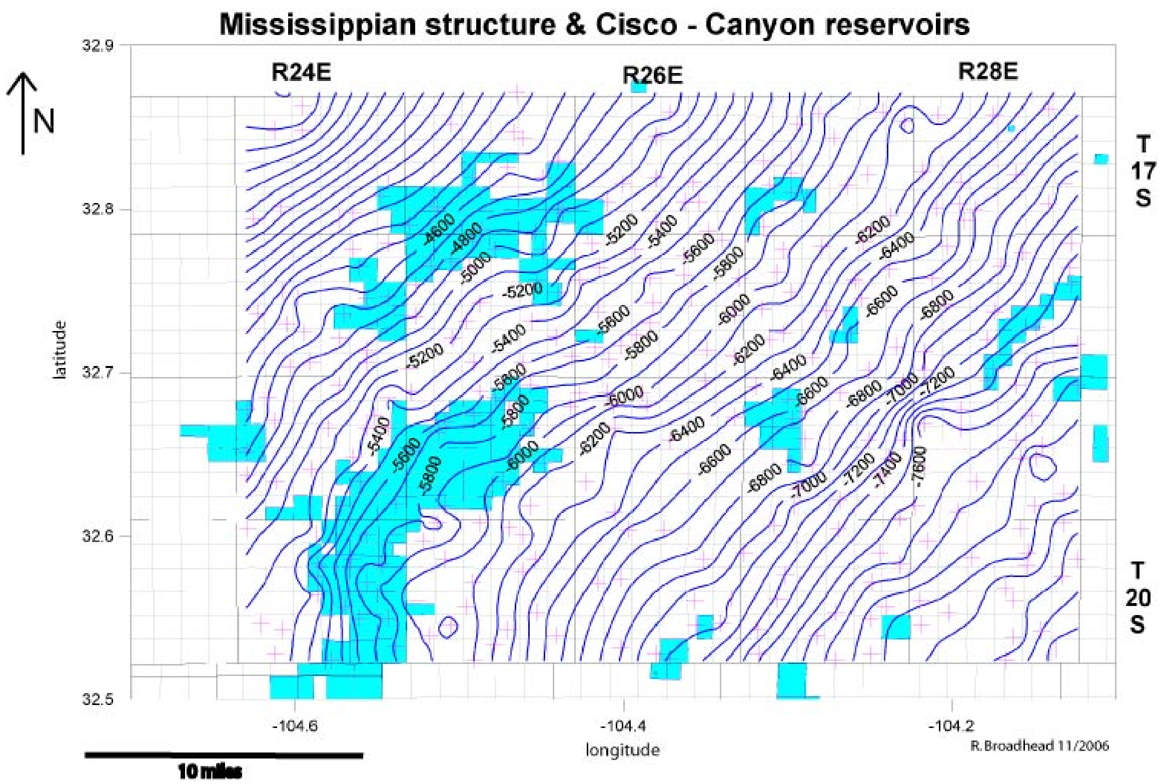


Fig. 3.57. Upper Pennsylvanian (Cisco and Canyon) reservoirs and Mississippian structure, shelf-margin project area.

The trend of the shelf-margin reservoirs is readily apparent on Figs. 3.58 and 3.59. The minor reservoirs south of the shelf margin may be formed by carbonate debris flows and their northern boundary may be identified by the shelf-margin trend apparent on Figs. 3.58 and 3.59. Reservoirs north of the shelf margin (e.g., Eagle Creek) appear to reside in somewhat younger strata than those of the shelf margin (e.g., Dagger Draw North) and are not resolved by maps prepared for this project.

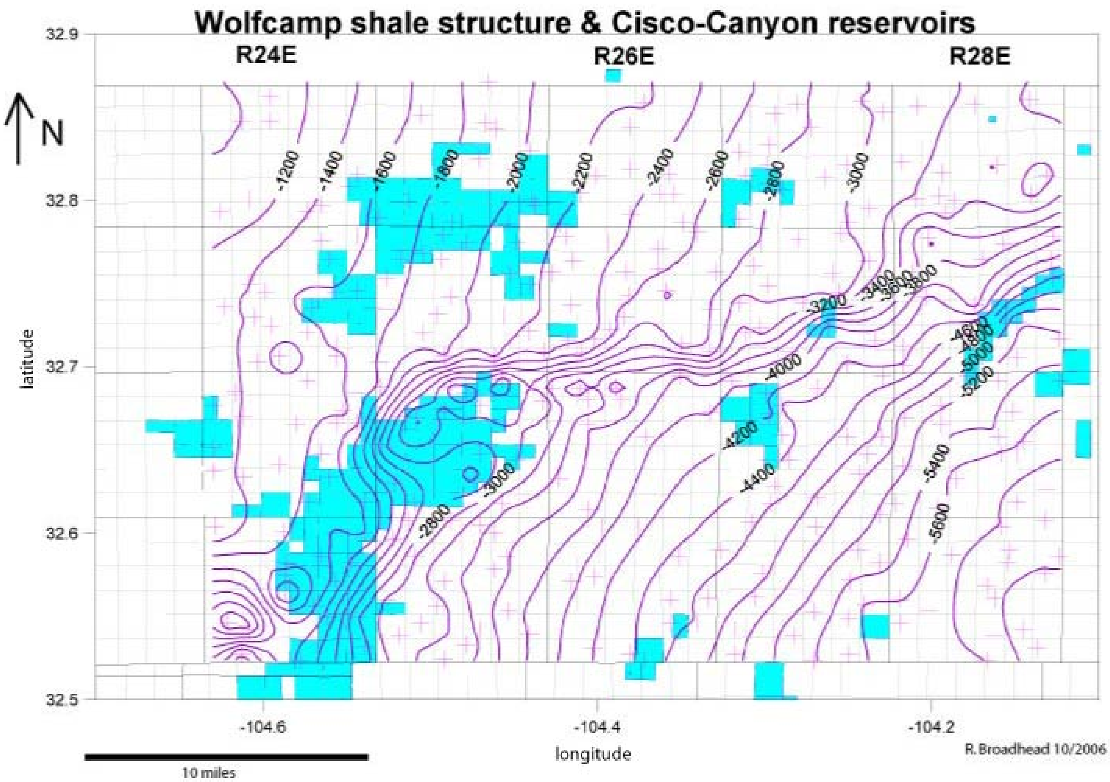


Fig. 3.58. Upper Pennsylvanian (Cisco and Canyon) reservoirs and upper Wolfcamp shale structure, shelf-margin project area.

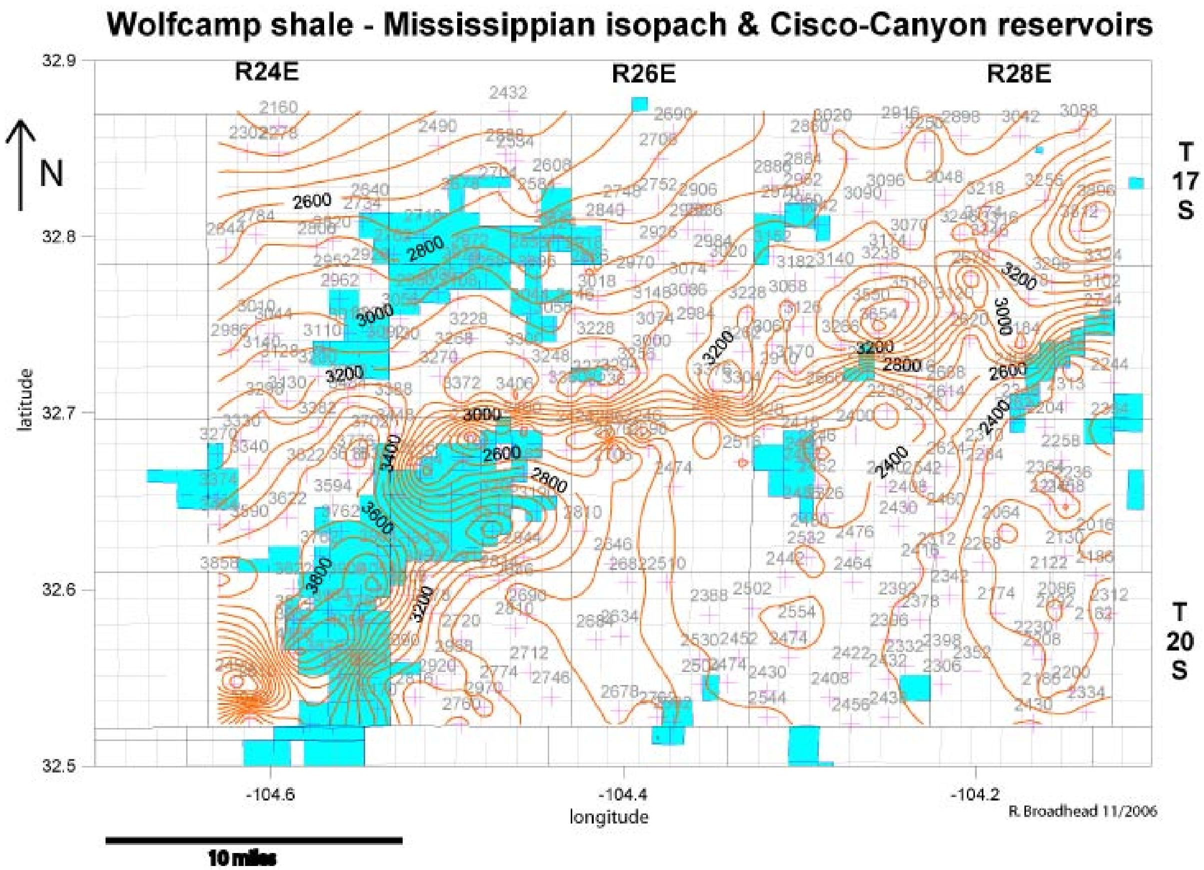


Fig. 3.59. Upper Pennsylvanian (Cisco and Canyon) reservoirs and isopach map of stratigraphic interval between the top of the upper Wolfcamp shale marker and the top of the Mississippian System, shelf-margin project area.

4. Task Four: Technology Transfer

An integral component of this project was an active and vigorous technology transfer program. Technology Transfer will continue past the scheduled end of the project. The Southwest section of the Petroleum Technology Transfer Council (PTTC) was housed in the same building as the PRRC and tech transfer remains a fundamental component of all research performed at the Center even with the restructuring of the PTTC. For the CFS project, a concerted effort has been made to constantly keep industry updated on developments through talks, presentations, and expansion of the FEE Tool consortium. The project actively transfers technology on both regional and national levels. In the first year, this included the papers and presentations listed below. The project has actively transferred technology on both regional and national levels; in the projects two years, this included the papers and presentations listed below:

1. Balch, R. S., Ruan, T. and Schrader, S.M.: "Fuzzy Expert Systems in Oil Exploration," SIAM Conference on Computational Science and Engineering, Orlando, FL, Feb. 12-15, 2005.

2. Schrader, S.M., Balch, R.S., Ruan, T.: "Using Neural Networks to Estimate Monthly Production: A Case Study for the Devonian Carbonates, Southeast New Mexico," paper SPE 94089, presented at the 2005 SPE Production and Operations Symposium, Oklahoma City, April 17-19.

3. Ruan, T., Balch, R.S., Schrader, S.M. and Hart, D.M.: "A Web-based Fuzzy Ranking System and Application," presented at the 9th World Multiconference on Systemics, Cybernetics and Informatics, Orlando, July 10-13, 2005
4. Ruan, T., Balch, R.S., Schrader, S.M.: "A Fuzzy Expert System for Oil Prospecting in the Lower Brushy Canyon of Southeast New Mexico," presented at the 2005 IEEE International Conference on Information Reuse and Integration, Las Vegas, August 15.
5. Schrader, S.M., Balch, R.S., and Ruan, T.: "Knowledge Management, Collection and Storage in Expert System Development," *Upstream CIO* (September 2005) 22-24.
6. Schrader, S.M., and Balch, R.S.: "Automated Analysis of Gridded Geologic Map Data," presented at the 2006 AAPG Annual Convention, Houston, April 9 -12.
7. Balch, R.S, Schrader, S.M, and Ruan, T.: "Knowledge Engineering: Collection, Storage and Applications of Human Knowledge in Expert System Development," accepted and in Press.
8. Sharp, J.: "Upper Pennsylvanian and Lower Permian phylloid algal mound

reservoirs, southeastern New Mexico," in Raines, M.A., ed., Resource plays in the Permian Basin: resource to reserves: West Texas Geological Society, Publication 06-117, p. 107-113, 2006.

The project has also graduated the following student topics:

1. Construction of a Knowledge Base using Efficient Algorithms in Knowledge Engineering, M.S., Rajani Goteti, December 2006.
2. Data Management Subsystem and the Online Expert Survey for the Customizable Fuzzy System, M.S., Obaid Khan, December 2006.

5. Experimental Methods

Laboratory experimentation was not a component of this project.

Technology Transfer

Technology transfer efforts comprised Task 4 of the project; they have been described in a previous section, "Task 4: Technology Transfer," under "Report Details."

Conclusions

The project has enjoyed a successful first and second year, with all project goals for the first and second budget periods met or exceeded. No significant obstacles have been identified. The project has reached the end of the primary software development stage and a functional prototype of the software has been implemented. The software is now ready for beta testing with outside users, which was scheduled for the third year of the project. The project is on task to produce expected results including deliverable software to aid and speed prospect generation using state-of-the-art computational intelligence technology. The project, unfortunately, has been discontinued due to lack of funding.

The system comprises four major components: a graphical user interface (GUI) for compiling and organizing expert knowledge, a GUI for organizing project data, a GUI for analyzing results, and a fuzzy inference engine for processing rules. The knowledge input into the system is to be expressed generally as “if-then” rules. Fuzzy rules will be employed when inputs are imprecise and factual data are insufficient or scarce. Local databases, such as the New Mexico Production Data System (ONGARD) located at the PRRC, and remote databases, such as “An Oil and Gas Development System,” supported by DOE, were to be linked to the customizable system through the Internet and would have allowed users to search for additional data. Final implementations and ease of use factors for the software were never implemented as they were scheduled for year three. Please refer to Appendix I to view the modified SOPO. Statistical tools and methods of interpretation have been designed to allow users to input raw data and calculate appropriate rules and analyses quickly and efficiently. This software is fully integrated and allows seamless integration of user data in the expert system design process. A new customizable fuzzy inference has been designed to provide the relational computations required to relate scarce local data with sparse regional data.

Collection and processing of test data, the Pennsylvanian Carbonates of SE New Mexico, has been completed. This test data set while originally collected to aid in finalizing the work flow operations and wizards necessary for accurate and efficient expert system design, by itself represents a valuable resource for anyone interested in the play.

During the first project year geologic data acquisition and analysis was completed on the Upper Pennsylvanian and Lower Permian carbonate reservoirs within the project areas in the Permian Basin of southeastern New Mexico. During 2006, work on the Bough intrashelf project area was completed. Geologic data was acquired, mapped and analyzed on a second project area, the shelf margin project area that includes the Upper Pennsylvanian Dagger Draw oil reservoirs. The second project area was added to diversify the expert system’s approach to prospecting for oil in carbonate stratigraphic traps. Although reservoirs in both areas are formed primarily by phylloid algal mounds that have seen multiple episodes of diagenesis, the reservoirs within the Bough intrashelf area grew on bathymetrically high paleostructures and the reservoirs within the shelf margin area grew primarily as bioherms on a constructional shelf margin and their geographic location does not appear to be related to paleostructures. Both of the project areas have significant production. The 58 Permo-Pennsylvanian reservoirs that are at least partially present within the Bough intrashelf project area have produced a combined total of 329 million bbls oil. The 24 Upper Pennsylvanian reservoirs within the shelf margin project area have produced a combined total of 83 million bbls oil. Data generated includes numerous maps shown in section 3 of this report.

Successful completion of this customizable fuzzy expert system will bring great computational power for regional play analysis to companies of all sizes—benefiting large companies interested in recompletion opportunities but having reduced domestic exploration budgets and small companies without the resources to maintain full-time multidisciplinary exploration staff. Ultimately, widespread use of this technology can increase efficiency and production from domestic oil and gas sources. Analysis of the Pennsylvanian carbonates, a significant by-passed pay play, should showcase the abilities of the software and provide immediately useful information to companies interested in developing production from that play. It is anticipated that all original project goals will be completed at a future date utilizing a different funding agency.

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APPENDIX I

REVISED SOPO

ATTACHMENT A
STATEMENT OF PROJECT OBJECTIVES
DE-FC26-04NT15512
REVISED MAY 2007 TO REFLECT A REDUCED BUDGET

A Customizable Fuzzy Expert System for Regional and Local Play Analysis

A. OBJECTIVES

The objective of this project is to create a user definable and customizable fuzzy expert system tool to dramatically speed local and regional play analysis and to reduce subsequent drilling risk. This general tool will not require significant knowledge of computer programming, and will guide users through the process of building a successful expert system to evaluate plays from field to basin scale using public and/or private data and their own or public expertise. To demonstrate the effectiveness of the tool a secondary objective of analyzing the Pennsylvanian play of SE New Mexico, a play with significant potential for by-passed pay, will be performed.

B. SCOPE OF WORK

The project goals will be accomplished by defining a large set of rules that will form default settings based on play type and dimensions, populating databases with rules, variables, and fuzzy sets, that can be defined or redefined on-demand. These rules will be customizable using a graphical interface to add, subtract or modify rules based on the users need. Fuzzy sets and rules will be scalable and easily configured, as well as self-checking for conflicts and consistency. To make so many features of a software package behave in this dynamic faction, without significant programming experience by the users, will require a shift in software design, to include numerous databases and self-propagating code.

Wizards for guiding users of any level of expertise through the process will be defined and coded, thus allowing explorationists to build expert systems without being expert computer scientists.

DELETED
~~Concurrently, public data will be organized for analyzing an outstanding, bypassed-pay play, the Pennsylvanian, of SE New Mexico, which will provide an example of the usage of the system while simultaneously providing a significant opportunity for identifying new reserves~~.

C. TASKS TO BE PERFORMED

Four major tasks are to be performed in order to accomplish the project goals. Task 1.0 is the development of a customizable Fuzzy Expert System, with the ability to self-generate software and fully customize integral components of the expert system for non-computer programmers. Task 2.0 is the development of interfaces to simplify the goals of Task 1.0. The creation of wizards to aid in the work flow process will make expert system development both quicker and easier.

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~~In Task 3.0 the system will be validated using the Pennsylvanian carbonate play of SE New Mexico. Development of this by-passed pay play will aid in the creation of Wizards to assist users in Task 2.0.~~

An ongoing effort in Tech Transfer comprises Task 4.0, as the ultimate test of the successful program will require that it is widely available and utilized.

Task 1.0 – Customizable Fuzzy Expert System

The primary goal of Task 1.0 is to create a customizable Fuzzy Expert System that can quickly and easily adapt to exploration problems in a wide range of settings, whether with little or significant user input and modifications. Task 1 is divided into three main subtasks.

Subtask 1.1 Generalized Knowledge Base

A basic set of rules for each major type of play will need to be established. This work has been completed for two types in the "Risk Reduction with a Fuzzy Expert Exploration Tool" project, [15] stratigraphic sedimentary and structural carbonate play-types. Stratigraphic carbonate, and structural sedimentary plays will need to have basic rules determined. This will be accomplished through interviews with explorationists familiar with those types of plays, and will be an early goal of the project, completed within the first six months. The existing consortium for the FEE Tool project will provide ample resources to obtain the data.

Subtask 1.2 Databases and Self Generating Software

The previous successful expert system for exploration was hard-coded in java. This system will necessarily be much more dynamic than this earlier system, as users will want to enter their own rules (knowledge) and parameters for defining the associated fuzzy ranges. This can be accomplished by storing rules, variables, and fuzzy set parameters in database files that are called by java classes designed to self-propagate. In other words, the software will access databases, determine the number and types of rules and variables, and then self-implement software to address the requirements. Similarly, fuzzy sets will be dynamically configurable to fit any needed distribution a rule requires. This task will allow the expert explorationists to perform jobs generally requiring significant programming expertise. It is expected that this subtask will occupy the first year of the project.

Subtask 1.3 Generalized Fuzzy Inference Engine

The generalized inference engine will need to access the rule and fuzzy set data stored in databases. At the core of the system, the inference engine organizes the rules, checks for conflicts and outputs a resulting interpretation, in this case, an estimate of how successful a prospect will be. A fuzzy inference engine is not dependent on large amounts of specific data and can perform inference with scarce data with properly formed questions. The challenge for developing this inference engine will be in allowing a large number of variables and ranges to be defined by the user. The software will need to adapt to each study based on an analysis of rules, variables, and fuzzy ranges described and stored in external database files that can and will be changed on demand by users. This subtask is expected to require the first two years of the project to complete and will be worked on in tandem with the database classes of subtask 1.2.

Task 2.0 – User Interfaces and Wizards

A key component to the success of the project is the ability of oil professionals to accomplish tasks normally requiring computer professionals; Task 2.0 addresses this need by building easy to use interfaces for data and knowledge management and wizards to assist in expert system development.

Subtask 2.1 Interfaces to Populate and Manage Knowledge Base

Three major interfaces will be required, an interface to manage a user's project data and maps, an interface to manage knowledge and rules related to the project, and an interface to customize and modify the inference process. These interfaces will need to graphically and easily allow users to organize their projects.

~~Subtask 2.2 Expert System Design Wizards~~

~~Wizards are graphical tools designed to assist a user in working through a process. They often involve a set of questions to set a baseline, then a set of steps to fill in details. A wizard will often run software at the end of the process. For this project wizards are needed to initialize user project databases, set default rules (determine play type and scale for example), and guide the user through the process of defining or modifying new rules, fuzzy sets and data to be used by the system.~~

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~~Task 3.0 – Application to Pennsylvanian Play~~

~~The application of the project to a real play will provide several valuable components to the development of the system. As a development tool it will aid in generating default rules for stratigraphic carbonate plays, it will assist in generating the tools and wizards needed by users, and it will likely result in increased interest and development in a play which has already produced the Dagger Draw field, which in itself reversed the decline of oil production in New Mexico. Two major sub-tasks are needed.~~

Subtask 3.1 Collect Data

Public data will be gathered for this project, and organized in a manner consistent with general company practices and guidelines developed for doing the same with a literature search. ~~A wizard~~

~~(subtask 2.2) will be developed to help users collect and organize their own project data and to format it for use with the system. As important as collecting the data will be for testing and development purposes,~~ an analysis of the data gathering process will ~~also~~ be beneficial for assisting future users. The process will be heavily documented ~~and built into a wizard or series of wizards~~.

~~Subtask 3.2 Application of Customizable Fuzzy System~~

~~The Pennsylvanian carbonates of SE New Mexico were first developed in the 1950s as a structural play. Reevaluation has indicated that it may be more of a stratigraphic play. Re-development at Dagger draw led to an incredibly prolific reservoir and production rates that reversed the decline in New Mexico's oil production. There are indications that other such fields may exist, perhaps not at the scale of Dagger Draw but the Pennsylvanian is rich with bypassed pay opportunities. The Delaware Basin FEE Tool, a precursor to the customizable system proposed here, identified 4500 undrilled prospects with potential recoverable reserves of 212 million bbls for the lower Brushy Canyon Formation. In addition to showcasing features and aiding in development, the analysis of the Pennsylvanian by the customizable system has very real opportunities to generate significant gas and oil potential in SE New Mexico.~~

Task 4.0 – Tech Transfer

An integral component of this project is an active and vigorous tech transfer program. The SW section of the PTTC is housed in the same building as the PRRC and tech transfer is a fundamental component of all research performed at the Center. For the customizable expert system, a concerted effort will be made to constantly keep industry updated on developments through talks, presentations, and expansion of the FEE Tool consortium. The project will actively transfer technology on both regional and national levels. It is anticipated that 8–16 papers in regional and national meetings will result from this work.

The Internet will play a key tech transfer role. Regularly updated project websites will keep consortium and other industry users current with project development and allow feedback to the development of the system and related tools during development. Tech transfer will be ongoing, starting with meetings with consortium members, visits to petroleum society meetings, and in the last two years, direct presentations of results at national meetings.

D. DELIVERABLES

Deliverables will include reports written and delivered as outlined in the "Federal Assistance Reporting Checklist." In addition, Monthly Project Status Reports will be submitted. These reports are informal status reports sent via email to the DOE Project Manager.

A list of other project deliverables, subdivided by task follows:

1. **Task 1.0 –** An on-demand, configurable, customizable Fuzzy Expert System with user tools to define or redefine knowledge, data, and inference parameters.
2. **Task 2.0 –** A system of wizards and GUIs that allow oil explorationists to do the work of expert programmers in developing personalized Fuzzy Expert Systems.

DELETED May 2007

3. ~~**Task 3.0** – Play analysis of the Pennsylvanian carbonates, SE New Mexico, complete with drilling risk assessment and listing of best potential drill-sites.~~

4. **Task 4.0 –** Web pages detailing project results ~~and giving access to project tools~~ via web or downloadable and installable files.

E. BRIEFINGS/TECHNICAL PRESENTATION

Briefings shall be given as needed to explain progress and results of the technical effort to the COR. The Principal Investigator will also provide and present technical papers at the DOE/NETL Bi-Annual Contractors Review Meeting. The National Energy Technology Laboratory (NETL) in Tulsa, Oklahoma is the implementation office for the Department of Energy - Fossil Energy National Oil Program. Credit to the National Energy Technology Laboratory shall be given verbally and/or in writing when research, resulting from funding through this office is presented publicly. Additionally, reasonable advanced notice will be given to NETL regarding presentations and workshops.

APPENDIX II

Spreadsheet data for Bough Greater Area, Bough Detailed Area, and Shelf Margin Area

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Operator	Lease Name	Well Number	API Number	Location (S-T-R)	Township (South)	Range (East)	Section	Loc in section	Latitude	Longitude	Elevation	Datum	Total depth	Abo top (ft)	Abo subsea elevation (ft)	Source Abo top	Mississippian top (ft)	Mississippian subsea elevation (ft)	Source Mississippian top	Abo-Miss thickness
2	Robert Enfield	Carson Federal	1	30-005-21041-0	3-9S-31E	9	31	3	1980 FS/990 FW	33.55985	-103.76945	4295	KB		6860	-2565	scout ticket	9626	-5331	log correlation	2766
3	Nortex G&O	Bounty 9 Federal	1	30-005-20799	9-9S-31E	9	31	9	1980 FN/660 FE	33.54895	-103.77493	4262	GL		6911	-2649	scout ticket	10437	-6175	log correlation	3526
4	Maralo	Chavelea-Carson	1		10-9S-31E	9	31	10	1980 FN/1980 FW	33.54898	-103.76627	4304	DF		6958	-2654	scout ticket	10454	-6150	log correlation	3496
5	Maralo	Chavelea-Carson	2	30-005-20592	16-9S-31E	9	31	16	1980 FN/1980 FE	33.53446	-103.77933	4244	GR		6903	-2659	scout ticket	10468	-6224	log correlation	3565
6	Hamon	Magnolia State	1		03-9S-32E	9	32	3	660 FN/1980 FE	33.56736	-103.65714	4419	DF		7220	-2801	log correlation	10440	-6021	log correlation	3220
7	Bell Petroleum	State 5	1	30-025-20380	5-9S-32E	9	32	5	1980 FS/660 FE	33.56012	-103.68801	4454	KB		7280	-2826	log correlation	11084	-6630	log correlation	3804
8	MW Pet	Button Up Unit	2	30-025-32625	10-9S-32E	9	32	10	600 FN/2305 FW	33.55200	-103.66093	4456	KB		7258	-2802	scout ticket	10278	-5822	log correlation	3020
9	Amerada	State SR A	1		14-9S-32E	9	32	14	660 FS/660 FW	33.52748	-103.64895	4346	DF		7185	-2839	scout ticket	10390	-6044	log correlation	3205
10	Yates Petroleum	Buffalo Wallow LA	1	30-025-27074	21-9S-32E	9	32	21	1980 FN/660 FE	33.52004	-103.67116	4374	KB		7322	-2948	log correlation	11598	-7224	log correlation	4276
11	Hanson	Beulah Federal (OWWO)	1		22-9S-32E	9	32	22	660 FN/660 FE	33.52382	-103.65329	4337	DF		7208	-2871	log correlation	10420	-6083	log correlation	3212
12	Amerada	Chartier	2		23-9S-32E	9	32	23	660 FN/660 FW	33.52385	-103.64896	4341	KB		7200	-2859	log correlation	10430	-6089	log correlation	3230
13	Phillips	Marg C	1	30-025-25027	24-9S-32E	9	32	24	660 FS/1980 FW	33.51258	-103.62680	4354	KB		7294	-2940	log correlation	10943	-6589	log correlation	3649
14	Spence Energy	Federal 25	1		25-9S-32E	9	32	25	1980 FS/1980 FE	33.50212	-103.62259	4317	KB		7230	-2913	scout ticket	10902	-6585	log correlation	3672
15	Petroleum Dev.	Flying M McKay Federal	1	30-025-26171	26-9S-32E	9	32	26	1980 FS/1980 FE	33.50219	-103.63996	4339	KB		7260	-2921	log correlation	10904	-6565	log correlation	3644
16	Phillips	Marg B	1	30-025-24971	36-9S-32E	9	32	36	660 FN/2130 FW	33.49490	-103.62646	4269	GR		7205	-2936	scout ticket	10847	-6578	log correlation	3642
17	Coastal States	Pure State	1		11-9S-33E	9	33	11	660 FS/2310 FW	33.54210	-103.53789	4358	KB		7647	-3289	scout ticket	11720	-7362	log correlation	4073
18	Magnolia	S.P. Johnson	1		12-9S-33E	9	33	12	660 FS/ 1980 FW	33.54227	-103.52171	4341	KB		7670	-3329	log correlation	11754	-7413	log correlation	4084
19	American Mannex	Flying M State OWWO	1		15-9S-33E	9	33	15	660 FN/660 FW	33.53839	-103.56110	4374	KB		7575	-3201	log correlation	11820	-7446	log correlation	4245
20	Petroleum Prod.	Sunray 682	1	30-025-00970-0	36-9S-33E	9	33	36	660 FS/1980 FW	33.48582	-103.52275	4286	KB		7670	-3384	log correlation	11714	-7428	scout ticket	4044
21	Kerr McGee	McMillan	1	30-025-30653	03-9S-34E	9	34	3	660 FN/1980 FE	33.55738	-103.44996	4265	KB		7664	-3399	log correlation	11732	-7467	log correlation	4068
22	TMBR/Sharp	Johnson Federal	1	30-025-32728	33-9S-34E	9	34	33	1650 FN/2100 FE	33.49353	-103.46686	4263	KB		7750	-3487	scout ticket	11950	-7687	log correlation	4200
23	Mark & Garner	Betenbough	2	MN 02644	12-9S-35E	9	35	12	660 FS/660 FW	33.54294	-103.31977	4130	DF		7665	-3535	scout ticket	11512	-7382	log correlation	3847
24	McGrath & Smith	Federal A-13 (OWWO)	1		13-9S-35E	9	35	13	660 FN/1980 FW	33.53935	-103.31541	4114	GL		7650	-3536	scout ticket	11742	-7628	log correlation	4092
25	Pan American	Federal	4A		13-9S-35E	9	35	13	2300FS/990FW	33.53296	-103.31866	4128	KB		7626	-3498	log correlation	11284	-7156	log correlation	3658
26	Tenneco	Betenbough B	3		14-9S-35E	9	35	14	660 FN/1980 FE	33.53935	-103.32841	4136	DF		7700	-3564	log correlation	11770	-7634	log correlation	4070
27	Yates Petroleum	Hilliard USA	1		17-9S-35E	9	35	17	330 FS/660 FE	33.52760	-103.37640	4165	GR		7706	-3541	scout ticket	11770	-7605	log correlation	4064
28	Amerada	Anderson A	1		19-9S-35E	9	35	19	660 FS/660 FE	33.51405	-103.39333	4183	KB		7735	-3552	scout ticket	11836	-7653	log correlation	4101
29	Maralo	Barnes 20 (OWWO)	WD-1	30-025-31601	20-9S-35E	9	35	20	766 FN/2201 FW	33.52459	-103.38403	4183	KB		7742	-3559	scout ticket	11900	-7717	log correlation	4158
30	Walter W. Anderso	S.E. Anderson Estate OWWO	1	30-025-20488	30-9S-35E	9	35	30	660 FN/1980 FE	33.51041	-103.39754	4186	GL		7744	-3558	scout ticket	11862	-7676	log correlation	4118
31	Tipton & Denton	Marathon State (OWWO)	1		32-9S-35E	9	35	32	660 FN/660 FW	33.49631	-103.38857	4169	KB		7735	-3566	log correlation	11912	-7743	log correlation	4177
32	H.L. Brown	Mobil Atlanic Federal	1		01-9S-36E	9	36	1	1980 FN/1980 FW	33.56466	-103.21181	4060	KB		7680	-3620	scout ticket	12000	-7940	log correlation	4320
33	Layton Enterprises	Fox A State	5	30-025-31343-0	2-9S-36E	9	36	2	2310 FN/2070 FW	33.56375	-103.22873	4070	KB		7714	-3644	log correlation	11928	-7858	log correlation	4214
34	Cobra O&G	Aleschire 9	1	30-025-33188	9-9S-36E	9	36	9	1870 FS/1944 FE	33.54628	-103.25943	4087	KB		7782	-3695	log correlation	12260	-8173	log correlation	4478
35	Layton Enterprises	El Zorro C Federal	1	30-025-03565-0	11-9S-36E	9	36	11	660 FN/1980 FW	33.55384	-103.22901	4063	DF		7714	-3651	log correlation	11944	-7881	log correlation	4230
36	R L Burns	Federal 13	1	30-025-25364	13-9S-36E	9	36	13	1980FS/660FE	33.53209	-103.20311	4034	KB		7732	-3698	log correlation	11922	-7888	log correlation	4190
37	Secon	Vineon	1		15-9S-36E	9	36	15	660 FS/810 FE	33.52856	-103.23826	4067	DF		7717	-3650	scout ticket	11812	-7745	log correlation	4095
38	Socony Mobil	Magnolia Santa Fe OWDD	2		20-9S-36E	9	36	20	1980 FS/660 FW	33.51763	-103.28533	4080	DF		7664	-3584	log correlation	11470	-7390	log correlation	3806
39	Magnolia	Santa Fe Pacific D	2		22-9S-36E	9	36	22	660 FS/1880 FE	33.51397	-103.24174	4047	DF		7693	-3646	log correlation	11622	-7575	log correlation	3929
40	Magnolia	Santa Fe Pacific E	2		23-9S-36E	9	36	23	1650 FS/1650 FW	33.51669	-103.23022	4037	DF		7714	-3677	log correlation	11722	-7685	log correlation	4008
41	jack Grynberg	sawyer	1		24-9S-36E	9	36	24	330FN/1650FW	33.52568	-103.21288	4047			7737	-3690	scout ticket	11846	-7799	log correlation	4109
42	Marbob Energy	Bobby Fee	1	30-025-34765	25-9S-36E	9	36	25	2252 FS/990 FW	33.50443	-103.21489	4018	KB		7725	-3707	log correlation	11684	-7666	log correlation	3959
43	Oil Development C	Santa Fe Pacific RR	2-26		26-9S-36E	9	36	26	660 FN/660 FE	33.51033	-103.22040	4031	KB		7714	-3683	log correlation	11640	-7609	log correlation	3926
44	Mid-Continent Pet.	Sawyer A	1		27-9S-36E	9	36	27	660FS/1980FE	33.49995	-103.24175	4033	KB		7710	-3677	log correlation	11565	-7532	log correlation	3855
45	Magnolia	Santa Fe E	2		29-9S-36E	9	36	29	1980 FN/660 FE	33.50661	-103.27227	4062	KB		7684	-3622	log correlation	11468	-7406	log correlation	3784
46	The Pure Oil	Federal D	1		31-9S-36E	9	36	31	660 FS/660 FE	33.48542	-103.28944	4070	DF		7670	-3600	log correlation	11338	-7268	log correlation	3668
47	Monterey Oil	Pure-Monterey St. Lea H OWDD	1		32-9S-36E	9	36	32	1920 FS/660 FW	33.48887	-103.28513	4065	DF		7676	-3611	log correlation	11478	-7413	log correlation	3802
48	Mobil	U.D. Sawyer OWDD	1	30-025-03627	33-9S-36E	9	36	33	660 FN/660 FE	33.49632	-103.25472	4043	DF		7764	-3721	log correlation	12004	-7961	log correlation	4240
49	The Texas Co.	U.D. Sawyer	2		34-9S-36E	9	36	34	1650 FN/1650 FE	33.49361	-103.24076	4035	KB		7710	-3675	log correlation	11584	-7549	log correlation	3874
50	Texas Crude	Texaco Sawyer	1		35-9S-36E	9	36	35	2310 FS/330 FW	33.49000	-103.23426	4029	KB		7734	-3705	log correlation	11718	-7689	log correlation	3984
51	Union Oil	Federal 6	1		06-10S-31E	10	31	6	2306 FN/1687 FW	33.47591	-103.81937	4172	KB		6752	-2580	scout ticket	10538	-6366	log correlation	3786
52	Pan American	Reid B	1		10-10S-31E	10	31	10	330 FS/1980 FW	33.45432	-103.76614	4423	KB		7182	-2759	log correlation	11086	-6663	log correlation	3904
53	G.E. Hall	State G	1		22-10S-31E	10	31	22	1980 FS/1986 FE	33.42985	-103.76215	4374	KB		7134	-2760	log correlation	11050	-6676	log correlation	3916
54	John L Cox	State 32	1	30-005-20642	32-10S-31E	10	31	32	660FS/660FE	33.39705	-103.79254	4507	KB		7252	-2745	log correlation	11010	-6503	log correlation	3758
55	Stanolind Oil & Gas	Polecat Canyon Unit OWPA	1		34-10S-31E	10	31	34	660 FN/660 FW	33.40807	-103.77080	4342	KB		7100	-2758	log correlation	10910	-6568	log correlation	3810
56	Aztec	Murphy Reid	1		35-10S-31E	10	31	35	860 FN/2070 FW	33.40753	-103.74882	4427	KB		7202	-2775	scout ticket	10980	-6553	log correlation	3778
57	Read & Stevens	North Mescalero	1	30-025-28201	2-10S-32E	10	32	2	1980 FS/660 FW	33.47350	-103.64862	4279	GR		7130	-2851	log correlation	10440	-6161	log correlation	3310
58	BTA	Clair (OWWO)	1		3-10S-32E	10	32	3	660 FN/1980 FE	33.48058	-103.65720	4321	GL		7180	-2859	log correlation	10614	-6293	log correlation	3434
59	Phillips	Sandgate OWPA	1		4-10S-32E	10	32	4	660 FS/663 FW	33.46983	-103.68361	4372	KB		7300	-2928	log correlation	11422	-7050	log correlation	4122
60	Sohio	State	1		09-10S-32E	10	32	9	1980 FS/1980 FW	33.45889	-103.67939	4374	KB		7280	-2906	log correlation	11394	-7020	log correlation	4114
61	Roger C. Hanks	Zapata State OWWO	1		10-10S-32E	10	32	10	660 FN/330 FE	33.46629	-103.65196	4333	DF		7150	-2817	scout ticket	10390	-6057	scout ticket	3240
62	Manzano Oil	Pistol Pete	1	30-025-00015-0	11-10S-32E	10	32	11	510 FN/660 FE	33.46655	-103.63555	4244	DF		7064	-2820	log correlation	10328	-6084	log correlation	3264
63	Cities Service	State BL	1		14-10S-32E	10	32	14	1980 FN/660 FW	33.44817	-103.64902	4347	KB		7124	-2777	log correlation	10186	-5839	log correlation	3062
64	Cabeen Exploration	White State	1		15-10S-32E	10	32	15	660 FN/660 FE	33.45174	-103.65330	4340	DF		7140	-2800	log correlation	10290	-5950	log correlation	3150
65	Natomas	State	1		19-10S-32E	10	32	19	860 FS/660 FW	33.42680	-103.71875	4398	KB		7178	-2780	log correlation	11064	-6666	log correlation	3886
66	Cities Service	State AD OWWO	2		22-10S-32E	10	32	22	3300 FN/660 FE	33.42998	-103.65350	4341	DF		7094	-2753	log correlation	10160	-5819	log correlation	3066
67	Cola	Sun State	1	30-025-26021	24-10S-32E	10	32	24	2130 FN/1980 FW	33.43310	-103.62725	4257	GR		7370	-3113	scout ticket	11170	-6913	log correlation	3800
68	Manzano Oil	Diamondback State	1	30-025-00029-0	25-10S-32E	10	32	25	660 FN/1980 FW	33.42261	-103.62730	4301	KB		7350	-3049	log correlation	11170	-6869	log correlation	3820
69	Jackson, Douglas &	State	1		27-10S-32E	10	32	27	660 FN/1980 FW	33.42264	-103.66222	4338	DF		7060	-2722	scout ticket	9772	-5434	log correlation	2712
70	Tipton Dwight	State DX OWWO	1	30-025-08000-0	33-10S-32E	10	32	33	1980 FN/1990 FW	33.40445	-103.67958	4343	GR		7110	-2767	scout ticket	10796	-6453	log correlation	3686
71	Ashmun & Hilliard	Lea State DE OWWO	1		34-10S-32E	10	32	34	660 FN/1980 FW	33.40813	-103.66227	4346	KB		7160	-2814	log correlation	DNP		log correlation	
72	Maurice Brown	Lane B (OWWO)	1	30-025-00974	01-10S-33E	10	33	1	1983 FN/1980 FW	33.47796	-103.52284	4264	KB		7670	-3406	scout ticket	11870	-7606	log correlation	4200
73	Haskins & Knickerb	Lane Ranch Unit OWPA	1		4-10S-33E	10	33	4	1980 FS/660 FE	33.47380	-103.56616	4270			7520	-3250	log correlation	11252	-6982	log correlation	3732
74	Continental Oil	State Lane Ranch Unit	1		9-10S-33E	10	33	9	1980 FS/1980 FE	33.45922	-103.57062	4224			7493	-3269	scout ticket	11406	-7182	log correlation	3913
75	BTA Oil	9011 JV-P Wolverine	1	30-025-30465-0	14-10S-33E	10	33	14	2150 FS/710 FW	33.44558	-103.54453	4205	GR		7628	-3423	scout ticket	11746	-7541	log correlation	4118
76	Tom Brown	Champlin State	1		26-10S-33E	10	33	26	2080FS/760FE	33.41651	-103.53191	4208	DF		7656	-3448	log correlation	DNP			
77	Western Reserves	State 26	2	30-025-30316	26-10S-33E	10	33	26	1910FS/1980FE	33.41599	-103.53591	4218	KB		7626	-3408	log correlation	11514	-7296	log correlation	3888
78	Southland Royalty	St. N.M. D OWDD	1		31-10S-33E	10	33	31	1980 FS/660 FE	33.40128	-103.60116	4247	DF		7320	-3073	scout ticket	11112	-6865	log correlation	3792

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
79	Jake L. Hamon	State OWPA	1		35-10S-33E	10	33	35	660 FN/660 FE	33.40898	-103.53156	4206			7668	-3462	scout ticket	12086	-7880	log correlation	4418
80	Yates Petroleum	Vada AVJ State	1	30-025-01813-0	3-10S-34E	10	34	3	1980 FS/660 FW	33.47467	-103.45784	4221	GR		7775	-3554	scout ticket	12168	-7947	log correlation	4393
81	Yates Petroleum	Taco AUK State	2	30-025-35148	10-10S-34E	10	34	10	660FN/660FE	33.46728	-103.44480	4215	KB		7730	-3515	log correlation	12036	-7821	log correlation	4306
82	Purvis Oil	State 15	1	30-025-23528-0	15-10S-34E	10	34	15	1980 FN/1980 FW	33.44913	-103.45354	4193	GR		7800	-3607	log correlation	12136	-7943	log correlation	4336
83	Skelly Oil	Blue Quail Unit OWWO	1		19-10S-34E	10	34	19	660 FS/1975.38 FW	33.42726	-103.50558	4229	DF		7737	-3508	scout ticket	12116	-7887	log correlation	4379
84	Tom Brown	Peveler	1		12-10S-35E	10	35	12	1980 FS/1980 FW	33.46000	-103.31521	4078			7837	-3759	scout ticket	12054	-7976	log correlation	4217
85	Yates Petroleum	Royal BAC State	1	30-025-01817	24-10S-34E	10	34	24	1980FS/660FE	33.43107	-103.41036	4168	KB		7800	-3632	log correlation	12270	-8102	log correlation	4470
86	Yates Petroleum	Judson AAU State	1	30-025-27125	26-10S-34E	10	34	26	1980FS/660FW	33.41645	-103.44061	4186	KB		7854	-3668	log correlation	12284	-8098	log correlation	4430
87	Humble	NM State BR	1		36-10S-34E	10	34	36	330FS/1980FE	33.39752	-103.41456	4132	KB		7830	-3698	log correlation	12242	-8110	log correlation	4412
88	Penrose	Peveler (OWWO)	1		33-10S-35E	10	35	33	1980 FN/1980 FW	33.40573	-103.36708	4083	KB		7848	-3765	scout ticket	12168	-8085	log correlation	4320
89	William K Young	Mattie price	1	30-025-27240	34-10S-35E	10	35	34	1980FN/660FE	33.40573	-103.34107	4055	KB		7868	-3813	log correlation	12230	-8175	log correlation	4362
90	Cities Service	State BP	1		02-10S-36E	10	36	2	660 FN/1980 FW	33.48184	-103.22881	4022	KB		7745	-3723	scout ticket	11730	-7708	log correlation	3985
91	Cobra O&G	State 3	1	30-025-33721	3-10S-36E	10	36	3	2310 FN/1650 FW	33.47722	-103.24722	4042	KB		7730	-3688	log correlation	11728	-7686	log correlation	3998
92	Max Pray	State E	2		5-10S-36E	10	36	5	660 FN/1980 FW	33.48179	-103.28075	4055	KB		7690	-3635	log correlation	11488	-7433	log correlation	3798
93	Phillips	Crosse OWPA	1		6-10S-36E	10	36	6	1980 FN/1980 FE	33.47820	-103.29375	4068			7770	-3702	log correlation	11802	-7734	log correlation	4032
94	Amerada	State CA	1		9-10S-36E	10	36	9	660 FS/660 FE	33.45642	-103.25471	4030	DF		7724	-3694	log correlation	11618	-7588	log correlation	3894
95	Byron	S. Crossroads Ut. (OWWO)	1		10-10S-36E	10	36	10	1980 FS/1980 FW	33.46005	-103.24606	4024	DF		7714	-3690	log correlation	11718	-7694	log correlation	4004
96	Magnolia	A.J. Crawford OWPA	1		14-10S-36E	10	36	14	1980 FS/660 FW	33.44554	-103.23306	4014	KB		7736	-3722	log correlation	11630	-7616	log correlation	3894
97	T.P. Coal & Oil	State O	1		15-10S-36E	10	36	15	1980 FS/1980 FE	33.44555	-103.24172	4016	KB		7756	-3740	log correlation	11690	-7674	log correlation	3934
98	Ralph Lowe	Crossroads State	1		16-10S-36E	10	36	16	660 FS/1980 FE	33.44188	-103.25909	4035	KB		7768	-3733	log correlation	11688	-7653	log correlation	3920
99	Ralph Lowe	Crossroads State	1A		21-10S-36E	10	36	21	510 FN/1980 FE	33.43866	-103.25900	4036	KB		7770	-3734	log correlation	11690	-7654	log correlation	3920
100	Cobra O&G	Gainer Unit	1	30-025-34201	22-10S-36E	10	36	22	1294 FN/39 FW	33.43651	-103.25243	4033	KB		7780	-3747	log correlation	11638	-7605	log correlation	3858
101	Flint Oil & Gas	Dickenson (OWWO)	1		29-10S-36E	10	36	29	1980 FN/660 FE	33.42008	-103.27205	4047	DF		7806	-3759	log correlation	11890	-7843	log correlation	4084
102	Magnolia	Dickinson heirs	1		33-10S-36E	10	36	33	660 FS/660 FW	33.39836	-103.26771	4019	DF		7804	-3785	log correlation	11702	-7683	log correlation	3898
103	Gulf Oil	O.L. Cryer	1		34-10S-36E	10	36	34	660 FS/1980 FW	33.39853	-103.24599	4019	DF		7770	-3751	log correlation	11700	-7681	log correlation	3930
104	U.S. Signal	Signal 72 A Federal	1	30-005-20415	6-11S-31E	11	31	6	1980 FS/1650 FW	33.39138	-103.86382	4163	DF		6620	-2457	scout ticket	9968	-5805	log correlation	3348
105	Atlantic Rfg.	Federal Union	1		7-11S-31E	11	31	7	1980 FS/590 FW	33.37678	-103.86719	4159			6673	-2514	scout ticket	10070	-5911	log correlation	3397
106	Champlin	State	1		13-11S-31E	11	31	13	1980 FN/1980 FW	33.36620	-103.77658	4461	KB		7218	-2757	scout ticket	11002	-6541	log correlation	3784
107	Morris R. Antweil	State C	1		16-11S-31E	11	31	16	660 FS/660 FE	33.35882	-103.81979	4477	DF		7210	-2733	log correlation	10978	-6501	log correlation	3768
108	Hassie Hunt Trust	Manery Elliott	1		22-11S-31E	11	31	22	660 FN/1980 FW	33.35522	-103.81116	4477			7230	-2753	log correlation	DNP			
109	Samedan Oil	Hunt State OWPA	1		23-11S-31E	11	31	23	660 FN/660 FW	33.35524	-103.79807	4457	GL		7210	-2753	log correlation	10966	-6509	log correlation	3756
110	Phillips	James OWPA	1		34-11S-31E	11	31	34	1981 FS/660 FW	33.31886	-103.81535	4478			7180	-2702	scout ticket	10900	-6422	log correlation	3720
111	John L. Cox	Proctor	1		7-11S-32E	11	32	7	660 FN/660 FW	33.38606	-103.76372	4472	GR		7240	-2768	scout ticket	11006	-6534	log correlation	3766
112	U.S. Smelting	Proctor	1		5-11S-32E	11	32	5	990FN/890FE	33.39235	-103.73396	4399	DF		7200	-2801	log correlation	11028	-6629	log correlation	3828
113	Jack F. Grimm	Chaste	1		8-11S-32E	11	32	8	660 FS/660 FE	33.37495	-103.73302	4412	KB		7140	-2728	log correlation	11060	-6648	log correlation	3920
114	Amerada	State MB	1		11-11S-32E	11	32	11	660FS/1980FE	33.37491	-103.68554	4364	DF		7120	-2756	log correlation	10514	-6150	log correlation	3394
115	Amerada	Crawley	1		12-11S-32E	11	32	12	660 FS/660 FW	33.37490	-103.67689	4357	DF		7108	-2751	log correlation	10568	-6211	log correlation	3460
116	The Texas Co.	State BO	5		13-11S-32E	11	32	13	1650 FS/660 FW	33.36371	-103.67675	4350			7096	-2746	log correlation	10360	-6010	log correlation	3264
117	Amerada	Robinson A	2		14-11S-32E	11	32	14	1980 FS./660 FE	33.36411	-103.68108	4351	DF		7074	-2723	log correlation	10292	-5941	log correlation	3218
118	Hamon & Anderson	Amerada State	1		16-11S-32E	11	32	16	660 FN/1980 FE	33.37135	-103.72010	4395	KB		7173	-2778	scout ticket	10922	-6527	log correlation	3749
119	Amerada	Robinson	2		23-11S-32E	11	32	23	1980FN/660FE	33.35323	-103.68108	4351	DF		7080	-2729	log correlation	10220	-5869	log correlation	3140
120	Amerada	State MA	1		24-11S-32E	11	32	24	660 FS/660 FW	33.34592	-103.67677	4341			7080	-2739	scout ticket	9994	-5653	log correlation	2914
121	Texaco	John H. Moore OWWO	1	30-025-00069	25-11S-32E	11	32	25	660 FN/660 FW	33.34229	-103.67680	4340	KB		7066	-2726	log correlation	9904	-5564	log correlation	2838
122	Mid Continent Oil	State 13 A OWPA	1		26-11S-32E	11	32	26	1980 FN/660 FE	33.33867	-103.68118	4346			7140	-2794	log correlation	10360	-6014	log correlation	3220
123	Morris R. Antweil	State BC OWWO	1		33-11S-32E	11	32	33	660 FS/660 FW	33.31691	-103.72887	4412			7290	-2878	log correlation	11230	-6818	log correlation	3940
124	Elk Oil	Moore	1	30-025-25434	36-11S-32E	11	32	36	660FS/1980FW	33.31684	-103.67255	4340	KB		7276	-2936	log correlation	11030	-6690	log correlation	3754
125	Yates Petroleum	Quetzal AQA State	1	30-025-33460	8-11S-33E	11	33	8	2060 FS/2090 FE	33.37885	-103.63419	4313	KB		7320	-3007	log correlation	10912	-6599	log correlation	3592
126	LBO New Mexico	State OG	2	30-025-31381	9-11S-33E	11	33	9	1980 FS/660 FW	33.37861	-103.62518	4305	KB		7360	-3055	log correlation	10908	-6603	log correlation	3548
127	Texas Pacific & Co	J.P. Collier OWWO	1		10-11S-33E	11	33	10	1980 FN/1980 FW	33.38230	-103.60376	4275	DF		7350	-3075	scout ticket	10820	-6545	log correlation	3470
128	Cabot	Mary Ellen Dallas OWWO	1	30-025-00997	15-11S-33E	11	33	15	660 FS/660 FE	33.36039	-103.59492	4261	KB		7292	-3031	log correlation	10620	-6359	log correlation	3328
129	Deane H. Stoltz	NBN State	1		16-11S-33E	11	33	16	660 FS/1982 FW	33.36044	-103.62090	4297	DF		7368	-3071	scout ticket	10840	-6543	log correlation	3472
130	Pan American	State DC	1		16-11S-33E	11	33	16	660 FS/660 FE	33.36049	-103.61224	4285	KB		7331	-3046	scout ticket	DNP			
131	Lone Star	Florence A. Marley OWWO	1		20-11S-33E	11	33	20	660 FN/1980 FW	33.35684	-103.63802	4312	DF		7335	-3023	log correlation	10840	-6528	log correlation	3505
132	Sinclair Oil & Gas	St. 262 Unit OWPA	1		22-11S-33E	11	33	22	1980 FN/1980 FE	33.35317	-103.59920	4251	GR		7293	-3042	log correlation	10546	-6295	log correlation	3253
133	H.L. Brown & W.J. I	State MPC	1		27-11S-33E	11	33	27	1980 FN/660 FE	33.33861	-103.59509	4264	KB		7280	-3016	scout ticket	10494	-6230	log correlation	3214
134	Amerada	Kelsay OWWO	1		28-11S-33E	11	33	28	660 FS/660 FW	33.33147	-103.62507	4290	KB		7278	-2988	log correlation	10620	-6330	log correlation	3342
135	Sunray DX Oil	New Mexico State AS	1		29-11S-33E	11	33	29	1980 FN/1980 FE	33.33871	-103.63378	4300	KB		7290	-2990	log correlation	DNP?			
136	Shell	State	1A		33-11S-33E	11	33	33	660FS/660FE	33.31697	-103.61224	4274	DF		7234	-2960	log correlation	10440	-6166	log correlation	3206
137	Amerada	State BT K	1		34-11S-33E	11	33	34	660 FS/1980 FW	33.31697	-103.60360	4265	DF		7260	-2995	log correlation	10420	-6155	log correlation	3160
138	Amerada	State BT K	5		35-11S-33E	11	33	35	1980FS/660FW	33.32061	-103.59080	4252	DF		7252	-3000	log correlation	10270	-6018	log correlation	3018
139	Yates Petroleum	Lagarto State Unit	3	30-025-01820-0	01-11S-34E	11	34	1	660 FS/660 FW	33.38936	-103.47015	4139	GL		7770	-3631	log correlation	12250	-8111	log correlation	4480
140	Yates Petroleum	Tenneco ADP State	1	30-025-25762-0	2-11S-34E	11	34	2	330 FS/990 FE	33.38846	-103.47558	4149	KB		7768	-3619	log correlation	12092	-7943	log correlation	4324
141	Sunset Internationa	Mobil State	1		3-11S-34E	11	34	3	660 FS/1980 FW	33.38945	-103.49605	4177	KB		7745	-3568	log correlation	12244	-8067	log correlation	4499
142	Mobil Oil	State GG	1		10-11S-34E	11	34	10	1980 FS/1980 FE	33.37849	-103.49606	4156	KB		7740	-3584	log correlation	12184	-8028	log correlation	4444
143	Hill & Meeker	State	1		11-11S-34E	11	34	11	1650 FN/2310 FE	33.38300	-103.47989	4154	KB		7760	-3606	log correlation	12110	-7956	log correlation	4350
144	Yates Petroleum	Twain BCW State	1	30-025-36258	12-11S-34E	11	34	12	760FN/660FW	33.38546	-103.47018	4151	KB		7776	-3625	log correlation	12185	-8034	log correlation	4409
145	Yates Petroleum	Lagarto State Unit	2	30-025-23005-0	13-11S-34E	11	34	13	330 FS/330 FE	33.35952	-103.45591	4152	KB		7840	-3688	log correlation	12290	-8138	log correlation	4450
146	Cameron	Bogle Farms	1		15-11S-34E	11	34	15	660 FS/660 FE	33.36036	-103.49165	4169	KB		7780	-3611	log correlation	12110	-7941	log correlation	4330
147	Yates Petroleum	Blitzen AUB State	1	30-025-01824-0	16-11S-34E	11	34	16	660 FS/660 FW	33.36042	-103.52201	4196	DF		7752	-3556	log correlation	12164	-7968	log correlation	4412
148	Yates Petroleum	Comet AUC State	1	30-025-20698-0	23-11S-34E	11	34	23	660 FS/1980 FE	33.34586	-103.47860	4157	KB		7758	-3601	log correlation	12140	-7983	log correlation	4382
149	Yates Petroleum	East Sand Springs Unit	2	30-025-34862	24-11S-34E	11	34	24	660 FS/1700 FW	33.34586	-103.46655	4161	KB		7777	-3616	scout ticket	12324	-8163	scout ticket	4547
150	Yates Petroleum	Donner AUH State	1	30-025-34860	26-11S-34E	11	34	26	660FN/1000FE	33.34223	-103.47540	4166	KB		7788	-3622	log correlation	12200	-8034	log correlation	4412
151	Yates Petroleum	Carper Mcalester ATE State	1	30-025-20388-0	25-11S-34E	11	34	25	660 FN/1650 FW	33.34223	-103.46672	4144	GR		7795	-3651	scout ticket	12282	-8138	log correlation	4487
152	Felmont	Felmont Skelly State	1		28-11S-34E	11	34	28	660 FS/760 FE	33.33133	-103.50919	4182	KB		7756	-3574	log correlation	12082	-7900	log correlation	4326
153	Humble	South Four Lakes Unit	4		35-11S-34E	11	34	35	660 FS/1980 FE	33.31694	-103.47860	4156	DF		7733	-3577	log correlation	11732	-7576	log correlation	3999
154	Yates Petroleum	East Sand Springs Unit	1	30-025-34790	5-11S-35E	11	35	5	1000 FN/660 FW	33.39376	-103.43585	4173	KB		7860	-3687	log correlation	12304	-8131	log correlation	4444
155	Manzano/Tri Servic	Snake Eyes State/ 1McKnight St.	1	30-025-22726	06-11S-35E	11	35	6	946 FN/660 FE	33.39386	-103.44018	4163	KB		7770	-3607	log correlation	12300	-8137	log correlation	4530
156	Signal Oil & Gas	West Ranger Lake Unit OWPA	1		17-11S-35E	11	35	17	660 FS/2080 FW	33.36028	-103.43113	4159			7840	-3681	log correlation	12320	-8161	log correlation	4480
157	Yates Petroleum	Lagarto State Unit	1	30-025-30676	18-11S-35E	11	35	18	660 FS/1839 FW	33.36040	-103.44881	4162	KB		7778	-3616	log correlation	12308	-8146	log correlation	4530
158	Yates Petroleum	Shell State	1	30-025-22842	22-11S-35E	11	35	22	1980FN/660FE	33.35328	-103.38834	4141	KB		7930	-3789	log correlation	12612	-8471	log correlation	4682
159	Sunray Mid-Contine	NM State L	1	30-025-02674	25-11S-35E	11	35	25	660FS/660FE	33.33140	-103.35394	4088	DF		7950	-3862	log correlation	12640	-8552	log correlation	4690

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
160	Humble	State X	1		31-11S-35E	11	35	31	660 FN/1980 FE	33.32766	-103.44445	4154	DF		7830	-3676	log correlation	12120	-7966	log correlation	4290
161	Kerr McGee	State 32	1	30-025-31243	32-11S-35E	11	35	32	2300FS/1650FW	33.32140	-103.43257	4178	KB		7930	-3752	log correlation	12250	-8072	log correlation	4320
162	Tom L Ingram	Granny	1		1-11S-36E	11	36	1	660FS/1980FE	33.38966	-103.25460	4020	KB		7810	-3790	log correlation	11702	-7682	log correlation	3892
163	Tennessee Gas/Me	State Gulf A/1 Phillips St.	1		22-11S-36E	11	36	22	660 FS/1980 FW	33.34592	-103.29333	4022	KB		7892	-3870	log correlation	12152	-8130	log correlation	4260
164	Southland Royalty	Gulf State	1		24-11S-36E	11	36	24	1980FN/1980FE	33.35323	-103.25451	4000	KB		7908	-3908	log correlation	12044	-8044	log correlation	4136
165	Snowden	Santa Fe	1		27-11S-36E	11	36	27	660 FS/1980 FW	33.33161	-103.29326	4021	KB		7904	-3883	log correlation	12044	-8023	log correlation	4140
166	Stone Petroleum	State	1	30-025-28367	33-11S-36E	11	36	33	1980FS/330FE	33.32078	-103.30080	4038	KB		7976	-3938	log correlation	12100	-8062	log correlation	4124
167	Pennzoil	Cone State	1		35-11S-36E	11	36	35	1980 FN/1980 FW	33.32438	-103.27603	3999	KB		7936	-3937	log correlation	12038	-8039	log correlation	4102
168	Enserch	State 13	1	30-005-20916	13-12S-32E	12	31	13	1980 FS/660 FW	33.27542	-103.78086	4440	KB		7292	-2852	log correlation	10954	-6514	log correlation	3662
169	Enserch	State 14	1	30-005-20981	14-12S-31E	12	31	14	1980 FN/660 FE	33.27909	-103.78520	4447	KB		7298	-2851	log correlation	10968	-6521	log correlation	3670
170	EP Operating	State 24	1	30-005-21059	24-12S-31E	12	31	24	660 FN/1980 FW	33.26819	-103.77645	4425	KB		7320	-2895	log correlation	11100	-6675	log correlation	3780
171	Strata	Faisan State	1	30-005-21124	36-12S-31E	12	31	36	1435FN/757FE	33.23695	-103.76803	4413	KB		7330	-2917	log correlation	11116	-6703	log correlation	3786
172	Jake L. Hamon	Chambers	1		1-12S-32E	12	32	1	2310 FS/330 FW	33.30689	-103.67793	4344	DF		7210	-2866	log correlation	10724	-6380	log correlation	3514
173	Amerada	State ECD	1		2-12S-32E	12	32	2	660 FS/1980 FW	33.30235	-103.69008	4381	DF		7232	-2851	log correlation	10454	-6073	log correlation	3222
174	Yates Petroleum	Winter State Unit	1	30-025-00089-0	3-12S-32E	12	32	3	660 FS/1933 FE	33.30238	-103.70289	4416	DF		7280	-2864	log correlation	10756	-6340	log correlation	3476
175	Robert N. Enfield	Murphy State	1		5-12S-32E	12	32	5	660 FN/660 FW	33.31332	-103.74605	4421	GR		7280	-2859	scout ticket	11200	-6779	log correlation	3920
176	The Texas Co.	State BE OWPA	1		6-12S-32E	12	32	6	1980 FS/2017 FW	33.30603	-103.75913	4430			7310	-2880	scout ticket	11310	-6880	log correlation	4000
177	Petroleum Dev Cor	Landlady	1	30-025-27506	8-12S-32E	12	32	8	1980 FS/1980 FE	33.29139	-103.73750	4409	KB		7278	-2869	log correlation	11170	-6761	log correlation	3892
178	Morris R. Antweil	Buddy	1	30-025-26218	9-12S-32E	12	32	9	660 FN/660 FW	33.29875	-103.72893	4407	KB		7284	-2877	log correlation	11020	-6613	log correlation	3736
179	Amerada	H.C. Posey	1		11-12S-32E	12	32	11	660 FS/1980 FE	33.28782	-103.68546	4350			7220	-2870	log correlation	10534	-6184	log correlation	3314
180	Amerada	WP East Caprock	3		14-12S-32E	12	32	14	660 FN/1980 FW	33.28420	-103.68999	4364	DF		7232	-2868	log correlation	10528	-6164	log correlation	3296
181	Dalco	Sun Texaco State	1	30-025-25154	20-12S-32E	12	32	20	860FN/560FE	33.26907	-103.73283	4387	DF		7290	-2903	log correlation	11108	-6721	log correlation	3818
182	Carper	Soldier Hill State AE	1		23-12S-32E	12	32	23	800 FN/1800 FW	33.26933	-103.69058	4348	KB		7190	-2842	log correlation	10492	-6144	log correlation	3302
183	Ashman & Hilliard	Hassie Hunt Trust State	1		26-12S-32E	12	32	26	1980 FS/1980 FW	33.24743	-103.68981	4342	KB		7280	-2938	log correlation	10470	-6128	log correlation	3190
184	Monsanto	Hope State OWWO	1		27-12S-32E	12	32	27	660 FS/660 FE	33.24387	-103.69847	4349	KB		7312	-2963	log correlation	10900	-6551	scout ticket	3588
185	Petroleum Corp. of	Livermore State	9		31-12S-32E	12	32	31	467 FN/1787 FW	33.24083	-103.75975	4396	KB		7250	-2854	log correlation	11100	-6704	log correlation	3850
186	Sundray Mid Contin	N.M. State	1		1-12S-33E	12	33	1	330 FN/330 FW	33.31428	-103.57435	4242	DF		7348	-3106	log correlation	10938	-6696	log correlation	3590
187	Amerada Petroleum	State BTA	1		2-12S-33E	12	33	2	1980 FS/1980 FE	33.30587	-103.58190	4235	DF		7274	-3039	log correlation	10304	-6069	log correlation	3030
188	Amerada	Caudle	2		3-12S-33E	12	33	3	660 FN/660 FW	33.31335	-103.60794	4262	DF		7230	-2968	log correlation	10400	-6138	log correlation	3170
189	John L Cox	State 8	1		8-12S-33E	12	33	8	1980FS/1980FE	33.29144	-103.63371	4249	KB		7358	-3109	log correlation	10960	-6711	log correlation	3602
190	Amerada	J.T. Caudle	1		10-12S-33E	12	33	10	1980 FN/660 FE	33.29507	-103.59492	4259	KB		7310	-3051	log correlation	10460	-6201	log correlation	3150
191	Amerada	Chambers	2		11-12S-33E	12	33	11	660 FN/1980 FW	33.29864	-103.58628	4249	DF		7298	-3049	log correlation	10360	-6111	log correlation	3062
192	John L. Cox	State 14	1	30-025-33817	14-12S-33E	12	33	14	1310 FS/1310 FE	33.27504	-103.57990	4261	KB		7330	-3069	log correlation	10576	-6315	log correlation	3246
193	Trainer C W	Hope State	1	30-025-01059-0	22-12S-33E	12	33	22	660 FS/660 FE	33.25833	-103.59489	4263	KB		7230	-2967	log correlation	10030	-5767	log correlation	2800
194	Amerada	State BTF	1		23-12S-33E	12	33	23	1980 FN/1980 FW	33.26600	-103.58628	4261	DF		7318	-3057	log correlation	10510	-6249	log correlation	3192
195	Shell	HT State	1		25-12S-33E	12	33	25	660 FS/660 FE	33.24393	-103.56034	4234	DF		7640	-3406	scout ticket	11758	-7524	log correlation	4118
196	Amerada	Birdie C. Roach	1		26-12S-33E	12	33	26	1980 FS/660 FW	33.24749	-103.59060	4249	DF		7230	-2981	log correlation	10130	-5881	log correlation	2900
197	Amerada	State BTB	1		26-12S-33E	12	33	26	660 FN/660 FW	33.25480	-103.59058	4259	DF		7190	-2931	log correlation	9866	-5607	log correlation	2676
198	Humble	S. Four Lakes Unit	3		01-12S-34E	12	34	1	660 FN/660 FW	33.31329	-103.46997	4159	KB		7780	-3621	log correlation	11794	-7635	log correlation	4014
199	Humble	S. Four Lakes Unit	2		2-12S-34E	12	34	2	1980 FN/1980 FE	33.30968	-103.47864	4157	KB		7743	-3586	log correlation	11578	-7421	log correlation	3835
200	Western States	Smelting State (OWWO)	1		09-12S-34E	12	34	9	1980 FN/1980 FW	33.29505	-103.51759	4190	KB		7774	-3584	log correlation	12070	-7880	log correlation	4296
201	Trice Prod. Co.	Four Lakes St. of N.M. OWWO	1		11-12S-34E	12	34	11	660 FN/1980 FW	33.29877	-103.48304	4163	DF		7816	-3653	log correlation	12260	-8097	log correlation	4444
202	Neville G. Penrose	State X	1		12-12S-34E	12	34	12	1980 FN/660 FW	33.29509	-103.46998	4151	DF		7800	-3649	log correlation	12070	-7919	log correlation	4270
203	Tenneco Oil	State QE-13	1	30-025-29634	13-12S-34E	12	34	13	660 FS/1980 FW	33.27329	-103.46554	4180	KB		7810	-3630	log correlation	12020	-7840	log correlation	4210
204	Phillips	Signal OWPA	1		19-12S-34E	12	34	19	1983 FW/660 FS	33.25841	-103.55196	4219	KB		7672	-3453	log correlation	11940	-7721	log correlation	4268
205	Phillips & T P Coal (	Ranger	1		23-12S-34E	12	34	23	660 FS/660 FE	33.25858	-103.47409	4151	DF		7782	-3631	log correlation	11930	-7779	log correlation	4148
206	Phillips	Ranger	20	30-025-31931	26-12S-34E	12	34	26	810 FN/660 FW	33.25453	-103.48706	4169	KB		7740	-3571	log correlation	11840	-7671	log correlation	4100
207	Marbob Energy	Gus State	1	30-025-34940	27-12S-34E	12	34	27	1900 FS/660 FE	33.24739	-103.49136	4170	KB		7723	-3553	scout ticket	11820	-7650	log correlation	4097
208	Midwest Oil	State A	1		28-12S-34E	12	34	28	660 FN/660 FE	33.25483	-103.50882	4180	KB		7770	-3590	log correlation	12120	-7940	log correlation	4350
209	Lignum Oil	State 30	1	30-025-08441-0	30-12S-34E	12	34	30	660 FN/1980 FE	33.25477	-103.54765	4215	KB		7712	-3497	log correlation	12020	-7805	log correlation	4308
210	Jake L. Hamon	St. of NM OWPA	1		32-12S-34E	12	34	32	660 FN/660 FE	33.24036	-103.52605	4200	KB		7760	-3560	log correlation	12080	-7880	log correlation	4320
211	Yates	Mocha State	2	30-025-36097	33-12S-34E	12	34	33	900FS/1350FW	33.23024	-103.51943	4194	KB		7752	-3558	log correlation	12268	-8074	log correlation	4516
212	Phillips	Tower	1A		34-12S-34E	12	34	34	1980FS/1980FW	33.23325	-103.50013	4176	KB		7774	-3598	log correlation	11940	-7764	log correlation	4166
213	Cayman	Amerada State	1		35-12S-34E	12	34	35	330 FN/660 FW	33.24127	-103.48705	4166	KB		7726	-3560	log correlation	11814	-7648	log correlation	4088
214	Austral	State E	1	30-025-02680	06-12S-35E	12	35	6	660 FS/1980 FE	33.30243	-103.44434	4144	KB		7848	-3704	scout ticket	12342	-8198	log correlation	4494
215	Yates Petroleum	Indigo State Unit	1	30-025-34991-0	7-12S-35E	12	35	7	660 FN/660 FE	33.29880	-103.43999	4123	GR		7884	-3761	log correlation	12542	-8419	log correlation	4658
216	Yates Petroleum	Koala AXZ State	1	30-025-35410	19-12S-35E	12	35	19	990FN/330FE	33.26886	-103.43887	4133	KB		7860	-3727	log correlation	12444	-8311	log correlation	4584
217	Skelly Oil	West Tatum Unit OWPA	1		26-12S-35E	12	35	26	660 FS/1980 FW	33.24396	-103.37956	4050	DF		8020	-3970	log correlation	13078	-9028	log correlation	5058
218	Arrington	Sprouting PMD	1	30-025-35566	28-12S-35E	12	35	28	1980FS/660FW	33.24761	-103.41836	4111	KB		7930	-3819	log correlation	13076	-8965	log correlation	5146
219	Flag Redfern Oil	Huber State	1	30-025-28902	33-12S-35E	12	35	33	1980 FS/1980 FE	33.23315	-103.40969	4084	KB		7890	-3806	log correlation	13028	-8944	log correlation	5138
220	Williamson, Brunne	Natural State	1		04-12S-36E	12	36	4	1980 FN/660 FW	33.30973	-103.31513	4039	DF		7920	-3881	scout ticket	12750	-8711	log correlation	4830
221	Harvey E Yates	Cameron State	1	30-025-20260	15-12S-36E	12	36	15	1980FS/1980FE	33.27706	-103.28902	4011	KB		8070	-4059	log correlation	12660	-8649	log correlation	4590
222	Sinclair Oil & Gas	W.H. Anderson	1		17-12S-36E	12	36	17	660 FS/1980 FE	33.27318	-103.32339	4013	KB		8056	-4043	log correlation	13148	-9135	log correlation	5092
223	Yates	Dizzy AYX State	1	30-025-35517	34-12S-36E	12	36	34	1980FN/660FE	33.23696	-103.28474	3985	KB		8144	-4159	log correlation	12986	-9001	log correlation	4842
224	Hilliard (Adobe)	Phillips State (Tatum unit)	1	30-025-25660	35-12S-36E	12	36	35	660 FN/990 FE	33.24059	-103.26853	3986	KB		8180	-4194	scout ticket	12922	-8936	log correlation	4742
225	Dalport Oil	Wolf Federal (OWWO)	1		6-13S-31E	13	31	6	660 FS/660 FE	33.21347	-103.85407	4031	DF		6750	-2719	log correlation	10420	-6389	log correlation	3670
226	Marbob Energy	Lambert 58 Deep Unit	1	30-005-21144	8-13S-31E	13	31	8	330 FN/1010 FW	33.21076	-103.84871	4053	KB		6792	-2739	log correlation	10425	-6372	log correlation	3633
227	Yates Petroleum	Butkis Deep Unit	1	30-005-21149	9-13S-31E	13	31	9	1723 FS/2006 FW	33.20188	-103.82822	4113	KB		6880	-2767	log correlation	10612	-6499	log correlation	3732
228	J & G Enterprise	Resistol	1	30-025-00210-0	3-13S-32E	13	32	3	653 FN/1980 FW	33.22588	-103.70737	4349	KB		7360	-3011	log correlation	11374	-7025	log correlation	4014
229	Western Oil	State RW (OWWO)	1	30-025-20737	10-13S-32E	13	32	10	2310 FN/330 FW	33.20684	-103.71266	4343	DF		7374	-3031	log correlation	11468	-7125	log correlation	4094
230	North Central Oil	State 14	1	30-025-31761	14-13S-32E	13	32	14	1981 FS/2319 FW	33.18968	-103.68877	4326	KB		7518	-3192	log correlation	11826	-7500	log correlation	4308
231	Wood & Locker	State BL (OWWO)	1	MN 00265	16-13S-32E	13	32	16	330 FN/1980 FW	33.19779	-103.72449	4358	KB		7370	-3012	log correlation	11330	-6972	log correlation	3960
232	The Superior Oil Co	State 335	1		19-13S-32E	13	32	19	1980 FS/1980 FE	33.17527	-103.75461	4387	KB		7370	-2983	log correlation	11404	-7017	log correlation	4034
233	Yates Petroleum	Drover State Unit	2	30-025-20405-0	20-13S-32E	13	32	20	1980 FN/660 FE	33.17871	-103.73310	4358	KB		7360	-3002	log correlation	11362	-7004	log correlation	4002
234	Yates Petroleum	Drover State Unit	1	30-025-30648	20-13S-32E	13	32	20	990FS/990FE	33.17253	-103.73418	4349	KB		7378	-3029	log correlation	11368	-7019	log correlation	3990
235	RK Petroleum	State	1		27-13S-32E	13	32	27	660 FN/1980 FE	33.16783	-103.70282	4328	KB		7430	-3102	log correlation	11280	-6952	log correlation	3850
236	C.H. Juni	Cabot State	1	30-025-24450	29-13S-32E	13	32	29	1980 FN/660 FE	33.16436	-103.73309	4356	KB		7404	-3048	log correlation	11390	-7034	log correlation	3986
237	Texas Pacific	SE Caprock	1		27-13S-32E	13	32	27	660FN/660FW	33.16783	-103.71147	4340	DF		7430	-3090	log correlation	11270	-6930	log correlation	3840
238	United States Smel	States A	1		31-13S-32E	13	32	31	1980 FN/660 FE	33.14982	-103.75017	4372	KB		7394	-3022	log correlation	11476	-7104	log correlation	4082
239	Texas Pacific Coal (	Dry Lake Unit	1		33-13S-32E	13	32	33	660 FS/1980 FE	33.14236	-103.72000	4360	DF		7460	-3100	log correlation	11394	-7034	log correlation	3934
240	Cactus Drillilng	Gross State	1A		34-13S-32E	13	32	34	1980 FN/1650 FW	33.14975	-103.70820	4335	DF		7436	-3101	log correlation	11214	-6879	log correlation	3778

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
241	Lawton Oil	State OWWO	2		10-13S-33E	13	33	10	660 FS/660 FE	33.20057	-103.59490	4261	DF		7530	-3269	log correlation	11768	-7507	log correlation	4238
242	Ohio Oil Co.	Trigg	1		20-13S-33E	13	33	20	660 FN/660 FE	33.18243	-103.62951	4280	DF		7590	-3310	log correlation	12168	-7888	log correlation	4578
243	Eason Oil	Wilbo	1A		22-13S-33E	13	33	22	660 FN/1980 FW	33.18240	-103.60357	4253	DF		7542	-3289	log correlation	11940	-7687	log correlation	4398
244	Tenneco	Lazy J Deep	1	30-025-29933	26-13S-33E	13	33	26	660FS/1980FE	33.15685	-103.58205	4227	KB		7666	-3439	log correlation	12023	-7796	log correlation	4357
245	Gulf Oil	Lea State AN	1		27-13S-33E	13	33	27	1980 FS/1980 FW	33.16047	-103.60367	4247	KB		7600	-3353	log correlation	12186	-7939	log correlation	4586
246	Maralo	State of NM (OWWO)	1		01-13S-34E	13	34	1	649 FN/1980 FW	33.22600	-103.46556	4138	KB		7802	-3664	log correlation	12092	-7954	log correlation	4290
247	Yates Petroleum	Mocha State	1	30-025-35761	2-13S-34E	13	34	2	1100FN/1980FW	33.22477	-103.48280	4163	KB		7870	-3707	log correlation	12748	-8585	log correlation	4878
248	Pennzoil	Humble Federal	1-14		14-13S-34E	13	34	14	660FS/660FW	33.18621	-103.48716	4156	KB		7782	-3626	log correlation	12576	-8420	log correlation	4794
249	C.W. Trainer	Betenbough	1		20-13S-34E	13	34	20	660 FS/1980 FW	33.17141	-103.53460	4181	KB		7830	-3649	log correlation	12982	-8801	log correlation	5152
250	Viking Petroleum	Dome Nonambre 31 State	1	30-025-27224	31-13S-34E	13	34	31	1980 FN/660 FE	33.14966	-103.54317	4177	KB		7882	-3705	log correlation	13158	-8981	mudlog	5276
251	Yates Petroleum	Ranger AHJ State	1	30-025-21923	32-13S-34E	13	34	32	2080FN/1980FW	33.14939	-103.53454	4193	KB		7896	-3703	log correlation	13110	-8917	log correlation	5214
252	Yates Petroleum	Chad AXA State	2	30-025-35656	36-13S-34E	13	34	36	990FS/1310FE	33.14343	-103.45927	4114	KB		8028	-3914	scout ticket	13488	-9374	scout ticket	5460
253	Union Texas	Shell State	1	30-025-23722	6-13S-35E	13	35	6	1980FN/660FW	33.22233	-103.45278	4130	KB		7850	-3720	log correlation	12014	-7884	log correlation	4164
254	Sharples Oil	Seth Alston	1		17-13S-35E	13	35	17	560 FS/660 FW	33.18591	-103.43565	4113	DF		7880	-3767	log correlation	13580	-9467	log correlation	5700
255	Ensign Operating	Key 20	1	30-025-36140	20-13S-35E	13	35	20	2480FN/870FE	33.17762	-103.42329	4097	KB		8004	-3907	log correlation	13320	-9223	log correlation	5316
256	Harvey Yates	Duncan Unit	3	30-025-28535-0	26-13S-35E	13	35	26	660 FS/1980 FW	33.15709	-103.37955	4039	KB		8200	-4161	log correlation	13436	-9397	log correlation	5236
257	Adobe Oil & Gas	State 4	1	30-025-26370	4-13S-36E	13	36	4	1980 FN/660 FW	33.22240	-103.31472	4012	KB		8132	-4120	log correlation	12974	-8962	log correlation	4842
258	Union Oil	Turner	1		5-13S-36E	13	36	5	660FN/660FW	33.22602	-103.33217	4024	KB		8044	-4020	log correlation	12754	-8730	log correlation	4710
259	Union Oil	R.W. Duncan	1		6-13S-36E	13	36	6	330 FS/330 FE	33.21415	-103.33537	4018	DF		8066	-4048	log correlation	12760	-8742	log correlation	4694
260	Freeport Oil	State	1		11-13S-36E	13	36	11	1650 FS/2310 FE	33.20339	-103.27280	3962	KB		8172	-4210	log correlation	12950	-8988	log correlation	4778
261	Harvey E Yates	McClish Unit	1	30-025-23223	26-13S-36E	13	36	26	660FS/660FW	33.15696	-103.28034	3953	KB		8294	-4341	log correlation	13444	-9491	log correlation	5150
262	Harvey E Yates	Heyco Betenbough (OWWO)	1		32-13S-36E	13	36	32	660 FN/1980 FW	33.15344	-103.32767	3995	KB		8240	-4245	log correlation	13382	-9387	log correlation	5142
263	Harvey Yates	McDonald Unit	1	30-025-27444	33-13S-36E	13	36	33	660 FS/990 FE	33.14248	-103.30291	3966	KB		8190	-4224	log correlation	13060	-9094	log correlation	4870
264	Harvey E Yates	McDonald	WD-3Y	30-025-28151	34-13S-36E	13	36	34	660FS/660FW	33.14250	-103.29752	3963	KB		8236	-4273	log correlation	13172	-9209	log correlation	4936
265	Gulf	Caprock Unit	1		34-14S-31E	14	31	34	660 FN/1980 FW	33.06473	-103.81087	4431	KB		7395	-2964	log correlation	11840	-7409	log correlation	4445
266	Midwest Oil	Mobil State	1		10-14S-32E	14	32	10	1874FS/1874FW	33.11680	-103.70731	4338	KB		7522	-3184	log correlation	12042	-7704	log correlation	4520
267	Marathon	State 15	1		15-14S-32E	14	32	15	1650 FN/1980 FE	33.10709	-103.70271	4329	KB		7544	-3215	log correlation	11808	-7479	log correlation	4264
268	Gulf Oil	Lea State AT	1		21-14S-32E	14	32	21	1980FN/1980FW	33.09175	-103.72438	4354	DF		7516	-3162	log correlation	11930	-7576	log correlation	4414
269	Shell	TU State	1		27-14S-32E	14	32	27	1980FN/1980FE	33.07745	-103.70340	4318	KB		7610	-3292	log correlation	12124	-7806	log correlation	4514
270	The Texas Compan	State AU	1		29-14S-32E	14	32	29	660 FN/660 FW	33.08086	-103.74593	4369	KB		7460	-3091	log correlation	12030	-7661	log correlation	4570
271	The Texas Compan	State AV	1		31-14S-32E	14	32	31	660 FS/1980 FW	33.05537	-103.75930	4349	DF		7510	-3161	log correlation	12208	-7859	log correlation	4698
272	Texas Co.	State AT	2		10-14S-33E	14	33	10	660 FS/560 FE	33.11342	-103.59489	4212	DF		7720	-3508	log correlation	12430	-8218	log correlation	4710
273	Yates	LDM Amoco GX State	1	30-025-25428	19-14S-33E	14	33	19	660FS/1926FW	33.08450	-103.65530	4278	KB		7770	-3492	log correlation	12540	-8262	log correlation	4770
274	Atlantic Rfg.	State RW (OWWO)	1		27-14S-33E	14	33	27	1980FS/1980FW	33.07351	-103.60384	4212	DF		7680	-3468	log correlation	12488	-8276	log correlation	4808
275	Adobe Oil & Gas	Gray 35	1	30-025-26609	35-14S-33E	14	33	35	660FS/1650FW	33.05525	-103.58754	4201	KB		7830	-3629	log correlation	12480	-8279	log correlation	4650
276	Gulf Oil	Saunders	1		34-14S-33E	14	33	34	660 FS/1980 FW	33.05525	-103.60368	4207	DF		7804	-3597	log correlation	12470	-8263	log correlation	4666
277	Pan American	East Saunders Unit	1		12-14S-34E	14	34	12	1980 FN/1980 FW	33.12067	-103.46576	4105	KB		8050	-3945	log correlation	13470	-9365	log correlation	5420
278	TMBR Sharp	TMBR State 16	1	30-025-34333	16-14S-34E	14	34	16	1250FN/2176FE	33.10812	-103.51350	4141	KB		8090	-3949	log correlation	13364	-9223	log correlation	5274
279	Kern County Land	State	1		17-14S-34E	14	34	17	1980FS/1980FW	33.10254	-103.53461	4167	KB		8073	-3906	log correlation	DNP			
280	Pecos Production	Fort 21	1	30-025-36272	21-14S-34E	14	34	21	2310FN/1978FE	33.09073	-103.51291	4143	KB		8044	-3901	log correlation	13498	-9355	log correlation	5454
281	Yates Petroleum	Papalotes	1	30-025-33275	34-14S-34E	14	34	34	1960FS/330FE	33.05892	-103.49037	4108	KB		8078	-3970	log correlation	13538	-9430	log correlation	5460
282	Marbob Energy	Unocal 9 State	1	30-025-20479	9-14S-35E	14	35	9	1980FN/660FW	33.12080	-103.41835	4061	KB		8122	-4061	log correlation	13580	-9519	log correlation	5458
283	Yates Petroleum	Mamalotes BAM	1	30-025-35899	36-14S-34E	14	34	36	825FS/1275FE	33.05578	-103.45914	4080	KB		8130	-4050	log correlation	13522	-9442	log correlation	5392
284	Amerada	State HA	1		19-14S-35E	14	35	19	660FN/1980FE	33.09521	-103.44408	4075	KB		8130	-4055	log correlation	13496	-9421	log correlation	5366
285	Blackwood & Nicho	Woodward	1		24-14S-35E	14	35	24	660 FS/660 FE	33.08434	-103.35363	3987	KB		8150	-4163	log correlation	13374	-9387	log correlation	5224
286	Yates	Woodward ABD	1	30-025-28933	24-14S-35E	14	35	24	1980FN/1980FE	33.09171	-103.35786	4002	KB		8204	-4202	log correlation	13500	-9498	log correlation	5296
287	Ocean Energy	Kukui 31	1	30-025-35861	31-14S-35E	14	35	31	1290FN/1980FE	33.06443	-103.44401	4073	KB		8358	-4285	log correlation	13432	-9359	log correlation	5074
288	Chesapeake	Markham 33	1	30-025-35981	33-14S-35E	14	35	33	1650FS/660FW	33.05807	-103.41818	4045	KB		8280	-4235	scout ticket	13528	-9483	log correlation	5248
289	Harvey E. Yates	McDonald	2	30-025-27721	3-14S-36E	14	36	3	660 FN/660 FW	33.13887	-103.29753	3961	KB		8206	-4245	log correlation	12930	-8969	log correlation	4724
290	Zapata & Leidtke	Danglade	1		3-14S-36E	14	36	3	2310FN/330FE	33.13435	-103.28362	3952	KB		8270	-4318	log correlation	13512	-9560	log correlation	5242
291	Harvey Yates	Richardson FEE	2		5-14S-36E	14	36	5	1980 FS/1980 FW	33.13164	-103.32727	3978	KB		8234	-4256	log correlation	13376	-9398	log correlation	5142
292	Texas Crude & Sin	Richardson	1		5-14S-36E	14	36	5	660FS/660FW	33.12800	-103.33208	3984	KB		8236	-4252	log correlation	13350	-9366	log correlation	5114
293	Yates Petroleum	Paton LJ	1	30-025-26542	7-14S-36E	14	36	7	1980FS/660FE	33.11702	-103.33626	3994	KB		8210	-4216	log correlation	13408	-9414	log correlation	5198
294	Harvey E Yates	Austin Monteith	0-025-2627	30-025-26271	8-14S-36E	14	36	8	1650FS/1980FW	33.11610	-103.32764	3981	KB		8206	-4225	log correlation	13346	-9365	log correlation	5140
295	Adobe Oil & Gas	State 16	1	30-025-25717	16-14S-36E	14	36	16	990FS/660FW	33.09990	-103.31445	3962	KB		8216	-4254	log correlation	13194	-9232	log correlation	4978
296	Phillips	Austin	1		17-14S-36E	14	36	17	661 FS/661 FW	33.09896	-103.33179	3981	KB		8180	-4199	log correlation	13182	-9201	log correlation	5002
297	Yates Petroleum	Barbee LL	1	30-025-26442	18-14S-36E	14	36	18	1980 FN/1980 FE	33.10615	-103.34051	3994	KB		8204	-4210	log correlation	13350	-9356	log correlation	5146
298	Harvey E Yates	Superior 19	1	30-025-26837	19-14S-36E	14	36	19	1980FN/660FE	33.09170	-103.33613	3985	KB		8122	-4137	log correlation	13216	-9231	log correlation	5094
299	Adobe Oil & Gas	Head State	1	30-025-27057	20-14S-36E	14	36	20	1980FN/1980FE	33.09173	-103.32311	3972	KB		8140	-4168	log correlation	13198	-9226	log correlation	5058
300	William K Young	Terry	1	30-025-26216	22-14S-36E	14	36	22	660FS/1980FE	33.08429	-103.28873	3942	KB		8290	-4348	log correlation	13566	-9624	log correlation	5276
301	Antares Oil Compar	Hannah	1		30-14S-36E	14	36	30	1980FN/660FW	33.07708	-103.34932	3988	KB		8100	-4112	log correlation	13384	-9396	log correlation	5284

Operator	Lease	Well #	Section	Placement	In Section	Latitude	Longitude	API #	KB Elev.	Top "A"	"A" Elev.	"A" Thick.	Top "B"	"B" Elev.	"B" Thick.	Top "C"	"C" Elev.	"C" Thick.	Top "D"	"D" Elev	Tot Thick.	Log #	Prod. Top	Prod. Bottom	Bough A Prod	Bough B Prod	Bough C Prod	Bough D Prod	Init Prod.	Cum Oil	Cum Gas	Cum Water	Field	Plugged
Philips Petroleum Compa	South Four Lakes U	1	2-12S-34E	660 FNL	1980 FEL	33.31331	-103.47861	30-025-01831	4161	9621	-5460	72	9693	-5532	120	9813	-5652	87	9900	-5739	279	2873	9888	10257			x	x	17 BO+10 BW	756198	1210983	54227	Four Lakes	1983
Sabine Corporation	Paris State	1	36-13S-32E	660 FSL	660 FEL	33.14243	-103.66381	30-025-23160	4297	9662	-5365	119	9781	-5484	67	9848	-5551	49	9897	-5600	235	48681	9852	9875			x		425 BO+343 BW	482870	1067450	667517	N Baum	1985
Pan American Petr. Corp	DC	1	16-11S-33E	660 FSL	660 FEL	33.36049	-103.61224		4285	9110	-4825	140	9250	-4965	104	9354	-5069	64	9418	-5133	308	47230	9261	9384		x	x		195 BO+454 BW	415535	2431637	971457	Bagley	
Amerada Petr. Corp.	WE Mathers B	1	33-11S-33E	1980 FNL	1980 FWL	33.32421	-103.62074		4281	8943	-4662	106	9049	-4768	121	9170	-4889	61	9231	-4950	288	6858	8641	8657					Too Shallow				Bagley	
Stoltz & Company	Lulu	1	4-11S-33E	656 FSL	1985 FWL	33.38962	-103.62093		4304	9300	-4996	148	9448	-5144	127	9575	-5271	92	9667	-5363	367	23367	9614	9672			x	x	336 BO+515 BW	356350	366867	1081798	North Bagley	
Bell Petroleum	State 21-K	1	21-11S-33E	1980 FSL	1980 FWL	33.34957	-103.62089		4271	8970	-4699	97	9067	-4796	113	9180	-4909	62	9242	-4971	272	35507	9839	9932					Too Deep				North Bagley	
Sunray DX Oil Co.	State of NM AO	1	16-10S-34E	660 FSL	660 FWL	33.44207	-103.47512	30-025-20470	4225	9730	-5505	68	9798	-5573	130	9928	-5703	67	9995	-5770	265	39558	9933	9939			x		230 BOPD	332642	279818	785415	Vada	1972
Coastal States Gas Prod	State 31	1	31-13S-33E	1881 FSL	759 FWL	33.14577	-103.65919		4300	9694	-5394	106	9800	-5500	66	9866	-5566	38	9904	-5604	210	46398	9889	9941			x	x	142 BO+509 BW	321793	518981	707288	Baum	
Charles B. Read	Apache	1	3-10S-33E	660 FSL	510 FEL	33.47046	-103.54844	30-025-22119	4255	9309	-5054	99	9408	-5153	92	9500	-5245	82	9582	-5327	273	21946	9597	9622				x	65 BO+825 BW	299881	1940914	874295	Vada	
Phillips Petr. Co.	Ranger Lake Unit T	2	25-12S-34E	330 FSL	330 FWL	33.25586	-103.47084	30-025-01855	4150	10095	-5945	70	10165	-6015	116	10281	-6131	61	10342	-6192	247	10263	10326	10336			x		304 BOPD	291094	272776	58081	Ranger Lake	1973
Phillips Petr. Co.	West Ranger Unit	1	23-12S-34E	660 FSL	660 FEL	33.25858	-103.47409	30-025-01846	4152	10090	-5938	53	10143	-5991	105	10248	-6096	102	10350	-6198	260	2886	10312	10351			x	x	406 BO	291094	272776	58081	Ranger Lake	1973
Charles B. Read	Continental State	1	18-10S-34E	1977 FNL	1970 FWL	33.44880	-103.50563		4209	9659	-5450	69	9728	-5519	135	9863	-5654					21959	9867	9871			x		360 BO+60 BW	261813	643528	231113	Vada	
J.C. Barnes Oil Company	Southern Natural	1	1-11S-33E	740 FNL	570 FEL	33.39395	-103.56006	30-025-21016	4201	9375	-5174	113	9488	-5287	83	9571	-5370	59	9630	-5429	255	37917	9690	9702				x	337 BO+30 BW	253541	796014	90489	Inbe	1973
Amoco	State AZ	1	34-12S-34E	660 FNL	660 FEL	33.24035	-103.49136		4164	9910	-5746	90	10000	-5836	143	10143	-5979	93	10236	-6072	326	2894	10216	10298			x	x	170 BO	236855	323804	118775	Ranger Lake	1973
Amoco Production	NM I State	1	11-10S-33E	660 FNL	660 FEL	33.46691	-103.53162	30-025-00979	4244	9452	-5208	97	9549	-5305	99	9648	-5404	78	9726	-5482	274	2817	9700	9712			x		125 BO+559 BW	220837	299216	354215	Vada	1975
Shell Oil Company	State HT	1	25-12S-33E	660 FSL	660 FEL	33.24393	-103.56034		4235	9820	-5585	69	9889	-5654	71	9960	-5725	69	10029	-5794	209	48519	9797	9947	x	x			179 BO+30 BW	220825	255169	382283	Hightower	
Amerada Petr. Corp.	State BTB	2	26-12S-33E	1980 FNL	1980 FWL	33.25118	-103.58627		4263	8751	-4488	79	8830	-4567	60	8890	-4627	118	9008	-4745	257	10736	8728	8768	x				624 BO+12 BW	216403	1395230	128057	Hightower	1990
Sun Oil Company DX Div	NM State "JJ"	1	23-13S-32E	660 FSL	1980 FEL	33.17151	-103.68536		4326	9483	-5157	66	9549	-5223	170	9719	-5393	52	9771	-5445	288	48686	9754	9796			x	x	93 BO+470 BW	213412	360624	368217	Baum	1989
Robert B. Holt	Aztec State	2	26-13S-32E	660 FNL	660 FEL	33.16790	-103.68108		4321	9466	-5145	75	9541	-5220	159	9700	-5379	52	9752	-5431	286	39571	9743	9799			x	x	521 BOPD	212040	111059	134752	Baum	
Jake L. Hamon	Chambers	1	1-12S-32E	2310 FSL	330 FWL	33.30689	-103.67793		4345	8880	-4535	140	9020	-4675	139	9159	-4814	87	9246	-4901	366	109	8400	8480					Too Shallow				E. Caprock	
Trice Production Compar	Lazy "J" B	1	34-13S-33E	660 FSL	660 FEL	33.14229	-103.59509		4225	9663	-5438	85	9748	-5523	74	9822	-5597	68	9890	-5665	227	3044	9820	9829		x	x		244 BO	194479	402499	19769	Lazy-J	
Robert B. Holt	Aztec State	4	25-13S-32E	554 FSL	554 FEL	33.1569421	-103.66425	30-025-23532	4304	9627	-5323	99	9726	-5422	82	9808	-5504	41	9849	-5545	222	46790	9816	9840			x		377 BO+1570 BW	186779	532241	1340750	Baum	
Texas Pacific Oil Co.	State AH	1	14-12S-34E	1980 FNL	1980 FWL	33.28059	-103.48298	30-025-21627	4162	9934	-5772	64	9998	-5836	102	10100	-5938	71	10171	-6009	237	37933	9930	9986	x				304 BO	185255	187632	430186	Ranger Lake	1975
Apache Oil Corp.	Midwest State	1	23-10S-33E	1980 FSL	1980 FEL	33.43076	-103.53591		4212	9580	-5368	94	9674	-5462	94	9768	-5556	62	9830	-5618	250	40244	9771	9777			x		176 BO+22 BW	183228	222956	372240	Inbe	1972
Coastal States Gas Prod	Federal "20"	2	20-13S-33E	660 FSL	1980 FWL	33.17138	-103.63830	30-025-22705	4275	9574	-5299	83	9657	-5382	74	9731	-5456	84	9815	-5540	241	46386	9736	9746			x		240 BOPD	174080	247962	80723	Baum	1972
Pan American Petr. Corp	State "DL"	1	13-13S-32E	1980 FSL	660 FEL	33.1899157	-103.66464	30-025-22775	4309	9553	-5244	69	9622	-5313	110	9732	-5423	78	9810	-5501	257	46788	9590	9928	x	x	x	x	6 BO+56 BW	169222	165689	170960	Baum	1991
Atlantic Richfield Co.	State BJ	1	9-10S-34E	1980 FNL	660 FWL	33.45987	-103.47515		4242	9738	-5496	70	9808	-5566	116	9924	-5682	54	9978	-5736	240	23897	9936	9942			x		299 BO+82 BW	161882	204847	50104	Vada	1974
Texaco Inc.	DM State NCT-1	1	21-13S-33E	660 FSL	1980 FWL	33.17140	-103.62093		4267	9530	-5263	98	9628	-5361	97	9725	-5458	78	9803	-5536	273	31501	9742	9792			x		445 BO+149 BW	160975	180910	233676	Lazy-J	SWD
Charles B. Read	Aztec	1	15-10S-33E	2130 FSL	660 FEL	33.44550	-103.54902	30-025-21927	4215	9441	-5226	93	9534	-5319	121	9655	-5440					21949	9665	9675			x		462 BO+105 BW	153298	301633	76654	Vada	1972
Monsanto Company	Lane-State	1-Y	30-10S-34E	660 FSL	760 FWL	33.41280	-103.50974	30-025-21940	4253	9593	-5340	69	9662	-5409	118	9780	-5527	55	9835	-5582	242	23973	10002	10014				x	60 BO+402 BW	150744	163703	429957	Vada	1975
Tom Brown Drilling Co. Ir	Holt State	1	4-10S-34E	766 FSL	554 FWL	33.47134	-103.47552	30-025-22458	4253	9724	-5471	76	9800	-5547	130	9930	-5677					40252	9934	9945			x		59 BO+975 BW	149084	424878	455533	Vada	
Sun Oil Company	NM "M" State	1	19-10S-34E	660 FNL	660 FWL	33.43807	-103.50992	30-025-22590	4227	9628	-5401	62	9690	-5463	98	9788	-5561	82	9870	-5643	242	40257	9897	9906				x	279 BO+221 BW	148040	696821	83393	Vada	1977
Sun Oil Company	NM "Q" State	2	9-11S-34E	660 FNL	1980 FWL	33.38591	-103.51775	30-025-23191	4233	9626	-5393	85	9711	-5478	134	9845	-5612	86	9931	-5698	305	46624	9958	9970				x	399 BO+93 BW	142931	330384	191284	Inbe	1977
Superior Oil Company	State "L" Com	1	33-13S-34E	510 FSL	660 FEL	33.14203	-103.50854	30-025-22725	4151	10245	-6094	103	10348	-6197	96	10444	-6293	56	10500	-6349	255	10746	10450	10454			x		184 BO	141063	188679	197808	Cerca	1983
A.F. Roberts, Jr.	Gulf State	1	18-11S-34E	660 FNL	660 FEL	33.37112	-103.54362	30-025-01825	4210	9701	-5491	82	9783	-5573	79	9862	-5652	67	9929	-5719	228	23752	9867	9875			x		322 BO+198 BW	132633	265375	232606	Inbe	1974
OXY USA	Elkan "A"	1	25-13S-34E	1650 FSL	990 FWL	33.1600095	-103.46959	30-025-29421	4128	10290	-6162	61	10351	-6223	105	10456	-6328	64	10520	-6392	230	48201	10488	10518			x		135 BO+22 BW	121103	97982	187184	Alston Ranch Upper Penn	1991
Texaco Inc.	State of NM "BV" N	3	36-13S-33E	990 FSL	990 FWL	33.14320	-103.57240		4206	9699	-5493	101	9800	-5594	129	9929	-5723	92	10021	-5815	322	46404	9702	9849	x	x			536 BO	119798	136168	483517	Lazy-J	SWD
Southland Royalty Co.	JD Guye	5	12-11S-33E	660 FSL	2030 FWL	33.37481	-103.56898	30-025-21367	4218	9336	-5118	91	9427	-5209	103	9530	-5312	76	9606	-5388	270	10723	9713	9730				x	190 BO+260 BW	116673	220033	58321	Inbe	1975
Humble Oil & Refg. Co.	NM State "BQ"	1	26-10S-33E	1980 FSL	660 FWL	33.41606	-103.54476	30-025-00987	4209	9540	-5331	98	9638	-5429	80	9718	-5509	67	9785	-5576	245	49044	9728	9734			x		279 BO+365 BW	115692	265354	204469	Inbe	1975
Getty (Skelly)	Willard Beaty	5	35-13S-33E	1650 FSL	660 FEL	33.14498	-103.57778	30-025-22010	4207	9685	-5478	127	9812	-5605	93	9905	-5698					37946	9842	9891		x			410 BO+8 BW	109772	392547	87171	Lazy-J	
Union Oil Co. of Californi	State "13"	1	13-10S-33E	1980 FNL	660 FWL	33.44865	-103.52731	30-025-22413	4213	9602	-5389	71	9673	-5460	122	9795	-5582					40266	9713	9722		x			317 BO+43 BW	109726	224009	33427	Inbe	1974
MGF Prodcution	Nine Ranch Inc Stat	3	22-10S-33E	1980 FSL	1980 FWL	33.43062	-103.55769	30-025-22302	4207	9505	-5298	89	9594	-5387	92	9686	-5479					23758	9692	9706			x		530 BO	104533	303620	54438	Inbe	1975
BTA Oil Producers	674 LTD Lane "C"	4	6-10S-34E	660 FNL	1980 FWL	33.48174	-103.50566		4276	9515	-5239	81	9596	-5320	114	9710	-5434					40254	9765	9775			x		282 BO+460 BW	101054	220990	312629	Vada	1975
Cabot Corporation	State "L"	1	23-11S-33E	1970 FNL	330 FWL	33.35315	-103.59164		4257	9055	-4798	135	9190	-4933	126	9316	-5059	77	9393	-5136	338	46619	9445	9458				x	200 BO+40 BW	99366	654034	0	North Bagley	1983
BTA Oil Producers	679 LTD MAR	2	5-10S-34E	660 FSL	660 FWL	33.47112	-103.49261		4253	9690	-5437	63	9753	-5500	125	9878	-5625					40253	9887	9894			x		298 BO+630 BW	98349	101484	163799	Vada	1975
BTA Oil Producers	Lane "A" 674 Ltd.	1	1-10S-33E	1980 FSL	1980 FEL	33.47426	-103.51863	30-025-00971	4254	9431	-5177	113	9544	-5290	116	9660	-5406	71	9731	-5477	300	2813	9656	9664		x	x		17 BO+558 BW	97981	119991	478616	Vada	1975
Gordon M. Cone	State 24	2	24-12S-34E	330 FSL	330 FEL	33.25754	-103.45586		4151	10110	-5959	65	10175	-6024	124	10299	-6148					2887	10310	10320			x		376 BOPD	91872	44720	140	Ranger Lake	1976
Texas Crude Oil Co.	State "26"	1	26-13S-33E	1980 FNL	1980 FEL	33.16414	-103.58200		4223	9673	-5450	83	9756	-5533	104	9860	-5637	74	9934	-5711	261	48677	9776	9852		x			210 BOPD	84657	161928	0	Lazy-J	
Gulf Oil Company	Lea State AN	1	27-13S-33E	1980 FSL	1980 FWL	33.16047	-103.60367	30-025-01087	4247	9569	-5322	67	9636	-5389	128	9764	-5517	73	9837	-5590	268	32729	9588	9625	x				998 BOPD	80895	0	0	Lazy-J	1957
Amerada Petr. Corp.	JT Caudle	3	10-12S-33E	660 FSL	660 FEL	33.29870	-103.59492		4258	8871	-4613	117	8988	-4730	140	9128	-4870	92	9220	-4962	349	182	9000	9045		x			308 BOPD	75334	59562	14981	Bagley	1974
Yates Petroleum	Pyro "ABK" State	1	33-13S-33E	660 FNL	1980 FEL	33.15321	-103.61665	30-025-29081	4262	9580	-5318	70	9650	-5388	84	9734	-5472	86	9820	-5558	240	36931	9783	9788			x		30 BO+450 BW	75154	158691	183270	Lazy-J	
Humble Oil & Refg. Co.	"CC" State	2	27-10S-33E	554 FSL	2086 FWL	33.41210	-103.55736	30-025-22060	4207	9486	-5279	102	9588	-5381	74	9662	-5455	57	9719	-5512	233	48788	9671	9689			x		244 BO+67 BW	68235	119550	18192	Inbe	1975
Phillips Petr. Co.	West Ranger Lake	16	26-12S-34E	1980 FSL	1980 FWL	33.2478924	-103.48339	30-025-22352	4160	10025	-5865	98	10123	-5963	117	10240	-6080	58	10298	-6138	273	37934	10245	10280			x		46 BO+330 BW	66112	48396	264889	Ranger Lake	
Champlin Petr. Co.	State "8"	1	8-10S-34E	660 FNL	660 FEL	33.46743	-103.47948	30-025-22585	4244	9712	-5468	73	9785	-5541	118	9903	-5659					40255	9908	9916			x		338 BO+74 BW	55395	86590	93945	Lane	
Aztec Oil and Gas & Delh	State LW	2	2-10S-33E	660 FNL	660 FEL	33.48156	-103.53146		4269	9439	-5170	107	9546	-5277	103	9649	-5380	75	9724	-5455	285	2814	9655	9770			x	x	173 BO+500 BW	51339	0	0	Lane WC	1960
Charles B. Read	State "D"	1	28-10S-33E	660 FNL	510 FEL	33.42336	-103.56582		4208	9410	-5202	87	9497	-5289	84	9581	-5373	56	9637	-5429	227	21956	9592	9606			x		240 BO+120 BW	48444	168535	155649	Inbe	1983
Harper Oil Company	Seay	1	30-12S-34E	660 FSL	660 FEL	33.2442377	-103.5441	30-025-26801	4220	9908	-5688	78	9986	-5766	68	10054	-5834	69	10123	-5903	215	49215	9920	9946	x				74 BO+82 BW	46765	54508	53578	Hightower	
Mesa Petroleum Compar	Humble CC State	7	34-10S-33E	2086 FNL	766 FWL	33.40485	-103.56171	30-025-21317	4211	9453	-5242	97	9550	-5339	90	9640	-5429					40248	9644	9658			x		276 BO+373 BW	45335	54389	149407	Inbe	1976
Amerada Petr. Corp.	Caudle	6	3-12S-33E	1980 FSL	1980 FWL	33.30603	-103.60370		4259	8840	-4581	121	8961	-4702	137	9098	-4839	100	9198	-4939	358	27775	9005	9064		x			74 BO+58 BW	39939	58536	258769	Bagley	1989
Sunray DX	NM State "AWA"	1	20-10S-34E	1980 FSL	660 FEL	33.43092	-103.47947	30-025-22528	4234	9660	-5426	80	9740	-5506	90	9830	-5596	70	9900	-5666	240	40259	9991	9999				x	377 BO+63 BW	32022	50713	131881	Vada	1972
Sam Boren Oil Co.	Boren-Barbera Stat	1	6-12S-34E	660 FSL	660 FWL	33.30219	-103.54353		4197	9403	-5206	78	9481	-5284	124	9605	-5408	83	9688	-5491	285	39569	9972	9976					Too Deep				Bagley Penn	1988
Cayman Corp.	Murphy State "A"	3	24-10S-33E	1980 FSL	660 FWL	33.43085	-103.52726		4222	9550	-5328	73	9623	-5401	88	9711	-5489	61	9772	-5550	222	22408	9838	9848				x	365 BO+91 BW	30223	71908	11181	Inbe	1973
American Oil	Candy Com	1	5-11S-33E	660 FSL	1980 FWL	33.38961	-103.63829		4320	9180	-4860	152	9332	-5012	129	9461	-5141	66	9527	-5207	347	46901	9221	9229	x				21 BO+94 BW	25005	0	93082	North Bagley	
Sam Boren	Crowley State "A"	1	5-12S-33E	1980 FSL	660 FWL	33.30599	-103.64226		4303	8970	-4667	102	9072	-4769	114	9186	-4883	80	9266	-4963	296	39566	9454	9466					Too Deep				North Bagley	1993
Amerada Petr. Corp.	CW Robinson A	1	14-11S-32E	660 FSL	660 FEL	33.36048	-103.68104		4361	9000	-4639	93	9093	-4732	89	9182	-4821	69	9251	-4890	251	72	9150	9232		x	x		16 BO	11480	738519	4399	Moore	
Texas Pacific Oil Co.	Viking State	1	16-12S-33E	660 FSL	660 FEL	33.28423	-103.61227	30-025-24140	4279	9038	-4759	124	9162	-4883	85	9247	-4968	104	9351	-5072	313	15645	9537	9625					Too Deep				North Bagley	1984
Charles B. Read	Continental State	2	7-10S-34E	660 FSL	660 FWL	33.45602	-103.50993	30-025-22740	4213	9639	-5426	72	9711	-5498	113	9824	-5611	53	9877	-5664	238	21958	9838	9842			x		321 BO+200 BW	8785	47910	434	Lane	
Coastal States Gas Prod	State 32 Com	2	32-13S-33E	660 FNL	1980 FWL	33.15321	-103.63845	30-025-22810	4283	9652	-5369	69	9721	-5438	76	9797	-5514	52	9849	-5566	197	46402	9850	9860				x	60 BO+480 BW	2904	1493	71297	Baum	1969
American Trading Prod.	State 22	1	22-12S-34E	555 FSL	555 FEL	33.25827	-103.49107	30-025-01844	4164	9965	-5801	51	10016	-5852	84	10100	-5936	49	10149	-5985	184	40784	10286	10343				x	193 BO+240 BW	1906	0	0	Ranger Lake	1967
Paul Decleva	Shell State	1	19-11S-34E	660 FSL	1830 FEL	33.35678	-103.54738		4214	9661	-5447	79	9740	-5526	80	9820	-5606	68	9888	-5674	227	35508	9905	9919				x	159 BO+320 BW	1730	12680	0	Inbe	1972
SW Natural Gas	TP State "4"	1	4-11S-34E	660 FSL	2100 FEL	33.38952	-103.51375		4231	9633	-5402	87	9720	-5489	130	9850	-5619	113	9963	-5732	330	23753	9972	9978				x	110 BO+198 BW	1718	3481	40470	Inbe	1974
Union Texas Petroleum C	State "24"	1	24-13S-32E	660 FSL	660 FWL	33.17154	-103.67674		4312	9480	-5168	71	9551	-5239	171	9722	-5410	52	9774	-5462	294	47255	9780	9789				x	38 BO+260 BW	1192	560	1758	N Baum	1971
McGrath & Smith, Inc.	McCrory	1	14-13S-34E	1980 FNL	660 FEL	33.19339	-103.47437		4146	10223	-6077	62	10285	-6139	79	10364	-6218	61	10425	-6279	202	46390							D & A	0	0	0	Wildcat	
Maralo	State of NM	1	1-13S-34E	649 FNL	1980 FWL	33.22600	-103.46556	30-025-01868	4139	10238	-6099	70	10308	-6169	97	10405	-6266	69	10474	-6335	236	3045							D & A	0	0	0	Wildcat	
Neville G. Penrose Inc.	State "X"	1	12-12S-34E	1980 FNL	660 FWL	33.29509	-103.46998		4152	9768	-5616	72	9840	-5688	150	9990	-5838	72	10062	-5910	294	197							P & A	0	0	0	Four Lakes	
Humble Oil & Refg. Co.	South 4 Lakes	3	1-12S-34E	660 FNL	660 FWL	33.31329	-103.46997		4159	9890	-5731	113	10003	-5844	159	10162	-6003	98	10260	-6101	370	2872							Too Deep	0	0	0	Four Lakes	
Yates Petroleum	Carper McCallister S	1	25-11S-34E	660 FNL	1650 FWL	33.34217	-103.46728	30-025-20388	4156	9949	-5793	86	10035	-5879	85	10120	-5964	58	10178	-6022	229	14777							D & A	0	0	0	Unnamed	
Earl T. Smith	Bogel Farms	1	13-11S-34E	330 FNL	330 FEL	33.3594331	-103.45655	30-025-23005	4152	10000	-5848	87	10087	-5935	70	10157	-6005	61	10218	-6066	218	47231							D & A	0	0	0	Wildcat	
Yates Petroleum	Lagarto State Unit	3	1-11S-34E	660 FSL	660 FWL	33.38936	-103.47015	30-025-01820	4151	9940	-5789	123	10063	-5912	90	10153	-6002	64	10217	-6066	277	6860							Too Deep	0	0	0	Sand Springs	
Sun Oil Company	State of NM "L"	1	21-10S-34E	519 FNL	803 FEL	33.43883	-103.46267		4210	9752	-5542	92	9844	-5634	116	9960	-5750					40260							D & A	0	0	0	Simanola	

Rice Eng. & Oper.	State NLA		3	3-10S-34E	1980 FSL	660 FWL	33.47467	-103.45784	30-025-01813	4232	9717	-5485	66	9783	-5551	124	9907	-5675	48	9955	-5723	238	2821			Too Deep	0	0	0	X-4 Ranch
Phillips Petr. Co.	Sandgate		1	4-10S-32E	660 FSL	663 FWL	33.46983	-103.68361		4372	9283	-4911	69	9352	-4980	105	9457	-5085	81	9538	-5166	255	2804			P & A	0	0	0	Wildcat
Sunray Mid-Continent Oil	State K		1	11-10S-32E	660 FSL	1980 FEL	33.45532	-103.64011		4271	9190	-4919	91	9281	-5010	76	9357	-5086	61	9418	-5147	228	23765			Out of Range	0	0	0	Wildcat
Yates Petroleum	Melinda State Unit		1	8-10S-33E	1980 FNL	660 FEL	33.46651	-103.58796	30-025-30748	4214	9316	-5102	91	9407	-5193	83	9490	-5276					43037			Too Shallow	0	0	0	Unnamed
Continental Oil Co.	State Lane Ranch		1	9-10S-33E	1980 FSL	1980 FEL	33.45922	-103.57062		4236	9403	-5167	88	9491	-5255	84	9575	-5339	73	9648	-5412	245	2816			P & A	0	0	0	Wildcat
Charles B. Read	Skelly State		2	10-10S-33E	2086 FNL	2086 FWL	33.46274	-103.55724		4243	9286	-5043	107	9393	-5150	91	9484	-5241	76	9560	-5317	274	21947			D & A	0	0	0	Lane
Midwest Oil	Nine Ranch		1	20-10S-33E	660 FNL	660 FWL	33.43744	-103.59676		4202	9310	-5108	105	9415	-5213	90	9505	-5303	65	9570	-5368	260	49040			D & A	0	0	0	Wildcat
Texas Pacific Oil Co.	State Bell		1	3-11S-33E	660 FSL	1980 FWL	33.38956	-103.60376		4284	9245	-4961	145	9390	-5106	106	9496	-5212	98	9594	-5310	349	47223			D & A	0	0	0	Unnamed
Texas Pacific Oil Co.	JP Collier		2	10-11S-33E	660 FNL	2130 FEL	33.38587	-103.59988		4274	9220	-4946	138	9358	-5084	115	9473	-5199	82	9555	-5281	335	49685			Too Deep	0	0	0	Bagley
Meadco Prop. Ltd.	Cabot-State		1	15-11S-33E	1980 FNL	660 FEL	33.36762	-103.59503		4265	9178	-4913	142	9320	-5055	100	9420	-5155	110	9530	-5265	352	47229			Too Deep	0	0	0	Bagley
Stoltz	State "262" unit		1	22-11S-33E	1980 FNL	1980 FEL	33.35317	-103.59920		4263	9044	-4781	140	9184	-4921	122	9306	-5043	74	9380	-5117	336	6856			Too Deep	0	0	0	Wildcat
HL Brown & WJ Heath	MPC State		1	27-11S-33E	1980 FNL	660 FEL	33.33861	-103.59509		4264	9015	-4751	131	9146	-4882	117	9263	-4999	78	9341	-5077	326	46765			Too Deep	0	0	0	Bagley
Amerada Petr. Corp.	State BT "O"		1	34-11S-33E	990 FSL	2310 FEL	33.31788	-103.60047		4260	8805	-4545	106	8911	-4651	157	9068	-4808	96	9164	-4904	359	6859			Too Deep	0	0	0	Bagley
The Texas Company	State "BC"		1	33-11S-32E	661 FNL	661 FWL	33.3170568	-103.7294	30-025-00074	4424	8713	-4289	71	8784	-4360	129	8913	-4489	57	8970	-4546	257	15906			D & A	0	0	0	Caprock
Jake Hamon & Anderson	Amerada State		1	16-11S-32E	660 FNL	1980 FEL	33.37135	-103.72010		4395	8931	-4536	78	9009	-4614	129	9138	-4743	78	9216	-4821	285	6853			P & A	0	0	0	Wildcat
Jack Grimm	Chaste		1	8-11S-32E	660 FSL	660 FEL	33.37495	-103.73302	30-025-23534	4412	8975	-4563	79	9054	-4642	156	9210	-4798	81	9291	-4879	316	46615			D & A	0	0	0	Wildcat
US Smelting, Refining & I	Proctor		1	5-11S-32E	990 FSL	890 FEL	33.39235	-103.73396		4400	8968	-4568	74	9042	-4642	151	9193	-4793	73	9266	-4866	298	46333			P & A	0	0	0	Wildcat
Harvey E. Yates Co.	Duncan Unit		2	26-13S-35E	1980 FNL	1980 FWL	33.1644791	-103.38015	30-025-27259	4038	10290	-6252	60	10350	-6312	140	10490	-6452	59	10549	-6511	259	46844	10240	10244	Too Shallow	0	0	0	Austin
Skelly Oil Co.	West Tatum Unit		1	26-12S-35E	660 FSL	1980 FWL	33.24396	-103.37956		4051	10179	-6128	50	10229	-6178	107	10336	-6285	64	10400	-6349	221	2952			P & A	0	0	0	Wildcat
Gulf Oil Company	Northwest Tatum U		1	10-12S-35E	1980 FSL	1980 FEL	33.29154	-103.39256		4123	10120	-5997	76	10196	-6073	147	10343	-6220	60	10403	-6280	283	46431			D & A	0	0	0	Wildcat
Roger Hanks	Shell State		1	22-11S-35E	1980 FNL	660 FEL	33.35328	-103.38834		4129	9950	-5821	108	10058	-5929	133	10191	-6062	56	10247	-6118	297	46767			D & A	0	0	0	Wildcat
Penroc Oil	Peveler		1	33-10S-35E	1980 FNL	1980 FWL	33.40573	-103.36708		4083	9823	-5740	139	9962	-5879	140	10102	-6019	88	10190	-6107	367	2825			P & A	0	0	0	Wildcat
Eason Oil Company	Wilbo	1-A		22-13S-33E	660 FNL	1980 FWL	33.18240	-103.60357		4254	9580	-5326	73	9653	-5399	80	9733	-5479	75	9808	-5554	228	46388			D & A	0	0	0	Wildcat
Lawton Oil Co.	State		2	10-13S-33E	660 FSL	660 FEL	33.2007604	-103.59562	30-025-01070	4262	9591	-5329	57	9648	-5386	72	9720	-5458	65	9785	-5523	194	15922			Too Deep	0	0	0	Wildcat
Amerada Petr. Corp.	Caudle		8	34-12S-33E	660 FNL	660 FEL	33.24027	-103.59483		4263	8685	-4422	70	8755	-4492	50	8805	-4542	75	8880	-4617	195	195			P & A	0	0	0	Hightower
Amerada Petr. Corp.	State BTG		2	27-12S-33E	660 FSL	660 FEL	33.24390	-103.59489		4268	8776	-4508	78	8854	-4586	46	8900	-4632	113	9013	-4745	237	194	8740	8772	Too Shallow	0	0	0	Hightower
Belco Petr. Corp.	State Lease K		1	22-12S-33E	660 FSL	660 FEL	33.2587944	-103.60844	30-025-23729	4276	9142	-4866	49	9191	-4915	109	9300	-5024	53	9353	-5077	211	49051			D & A	0	0	0	Hightower
Charles B. Read	Natural		1	15-12S-33E	660 FNL	1980 FEL	33.28416	-103.59924		4269	8936	-4667	115	9051	-4782	144	9195	-4926	60	9255	-4986	319	21473			Too Shallow	0	0	0	Bagley
US Smelting, Refining & I	State "A-31"		1	31-13S-32E	1980 FNL	660 FEL	33.14982	-103.75017		4372	8953	-4581	77	9030	-4658	167	9197	-4825	51	9248	-4876	295	3039			D & A	0	0	0	Wildcat
Superior Oil Company	State "335"		1	19-13S-32E	1980 FSL	1980 FEL	33.17527	-103.75461		4387	8923	-4536	138	9061	-4674	163	9224	-4837	71	9295	-4908	372	23402			Too Deep	0	0	0	Williams
Yates Petroleum	Drover State		2	20-13S-32E	1980 FNL	660 FEL	33.1790091	-103.73374	30-025-20405	4358	8980	-4622	130	9110	-4752	131	9241	-4883	56	9297	-4939	317	46394			P & A	0	0	0	Williams
Wood & Locker	State "BL"		1	16-13S-32E	330 FNL	1980 FNL	33.1980503	-103.7251	30-025-00265	4358	8938	-4580	124	9062	-4704	121	9183	-4825	59	9242	-4884	304	3027			Too Deep	0	0	0	Wildcat
Western Oil	State RW		1	10-13S-32E	2310 FNL	330 FWL	33.207124	-103.71328	30-025-20737	4344	8945	-4601	122	9067	-4723	115	9182	-4838	65	9247	-4903	302	10191			Too Deep	0	0	0	Wildcat
Amerada Petr. Corp.	State Caprock B		1	3-13S-32E	653 FNL	1980 FWL	33.22588	-103.70737	30-025-00210	4348	8857	-4509	131	8988	-4640	116	9104	-4756	81	9185	-4837	328	3025			D & A	0	0	0	Wildcat
Monsanto Company	Hope State		1	27-12S-32E	660 FSL	660 FEL	33.24387	-103.69847		4349	8555	-4206	72	8627	-4278	106	8733	-4384	65	8798	-4449	243	46826			P & A	0	0	0	Wildcat
Dalco Oil Company	Sun-Texaco State		1	20-12S-32E	860 FNL	560 FEL	33.2691668	-103.73345	30-025-25154	4388	8758	-4370	53	8811	-4423	118	8929	-4541	67	8996	-4608	238	46670			D & A	0	0	0	Wildcat
Chambers & Kennedy	Northwest Caprock		1	8-12S-32E	660 FNL	1980 FWL	33.29877	-103.74170		4418	8960	-4542	44	9004	-4586	144	9148	-4730	42	9190	-4772	230	2865			P & A	0	0	0	Wildcat
Robert Enfield	Murphy State		1	5-12S-32E	660 FNL	660 FWL	33.31332	-103.74605		4438	8994	-4556	48	9042	-4604	140	9182	-4744	48	9230	-4792	236	46346			D & A	0	0	0	Wildcat
Natomas North America,	State of NM		1	19-10S-32E	860 FSL	660 FWL	33.4267834	-103.71934	30-025-25846	4397	9297	-4900	75	9372	-4975	107	9479	-5082	82	9561	-5164	264	46881			Too Deep	0	0	0	Wildcat
MNJ Production	Citgo State		1	28-10S-32E	660 FSL	660 FWL	33.41171	-103.68394		4365	8798	-4433	60	8858	-4493	129	8987	-4622	63	9050	-4685	252	2810			D & A	0	0	0	Mescalero
Ralph Lowe	Mescalero State		1	27-10S-32E	1980 FNL	2310 FWL	33.41902	-103.66115		4342	8851	-4509	51	8902	-4560	98	9000	-4658	90	9090	-4748	239	46255			Too Deep	0	0	0	Devonian
Shell Oil Company	State "MS"		1	26-10S-32E	330 FNL	2310 FEL	33.423672	-103.64198	30-025-21338	4311	9378	-5067	90	9468	-5157	121	9589	-5278	71	9660	-5349	282	40155			D & A	0	0	0	Cuerno Largo
Manzano Oil	Diamondback State		1	25-10S-32E	660 FNL	1980 FWL	33.4228162	-103.62786	30-025-00029	4301	9308	-5007	83	9391	-5090	87	9478	-5177	54	9532	-5231	224	35344	9196	9244	Too Shallow	0	0	0	Cuerno Largo
Yates Petroleum	Mescalero LB St.		1	30-10S-33E	1980 FSL	1980 FEL	33.4156331	-103.60605	30-025-26300	4236	9339	-5103	74	9413	-5177	99	9512	-5276	65	9577	-5341	238	35348			D & A	0	0	0	Wildcat
Cabot Corporation	State "S"		1	29-10S-34E	660 FNL	1980 FWL	33.42365	-103.48827		4245	9597	-5352	109	9706	-5461	116	9822	-5577	77	9899	-5654	302	40262			D & A	0	0	0	Unnamed
Shell Oil Company	Royal Unit		1	24-10S-34E	1980 FSL	660 FEL	33.4308488	-103.41095	30-025-01817	4163	9745	-5582	144	9889	-5726	115	10004	-5841	66	10070	-5907	325	2823			P & A	0	0	0	Wildcat
William K Young Compar	Mattie Price		1	34-10S-35E	1980 FNL	660 FEL	33.4054818	-103.3417	30-025-27240	4055	9840	-5785	132	9972	-5917	151	10123	-6068	66	10189	-6134	349	46813			D & A	0	0	0	Wildcat
Amerada Petr. Corp.	State MB		1	11-11S-32E	660 FSL	1980 FEL	33.37491	-103.68554		4369	8944	-4575	81	9025	-4656	110	9135	-4766	63	9198	-4829	254	15902			P & A	0	0	0	Wildcat
Amerada Petr. Corp.	H.A. Crowley		1	12-11S-32E	660 FSL	660 FWL	33.37490	-103.67689		4358	8872	-4514	71	8943	-4585	107	9050	-4692	56	9106	-4748	234	6852			P & A	0	0	0	Moore
Manzano Oil	Sunburst "A" St. Co		1	7-11S-33E	1874 FSL	766 FEL	33.37838	-103.64719	30-025-29004	4326	8792	-4466	139	8931	-4605	114	9045	-4719	67	9112	-4786	320	15051			Too Deep	0	0	0	Bagley
Sam Boren	Gulf Sohio State		1	8-11S-33E	1980 FNL	660 FEL	33.38236	-103.62952		4307	9240	-4933	153	9393	-5086	129	9522	-5215	90	9612	-5305	372	17182			Too Deep	0	0	0	Wildcat
Sam Boren Oil Co.	Collier		1	9-11S-33E	660 FNL	810 FWL	33.38599	-103.62473		4311	9268	-4957	150	9418	-5107	128	9546	-5235	89	9635	-5324	367	47225			Too Deep	0	0	0	Bagley
Sunset International Petr	TP State		2	11-11S-33E	2086 FSL	2086 FEL	33.37873	-103.58248		4247	9102	-4855	115	9217	-4970	91	9308	-5061	59	9367	-5120	265	40622			P & A	0	0	0	Bagley
Sun Oil Company	State "A"		1	7-11S-34E	660 FSL	1830 FEL	33.37475	-103.54746		4212	9718	-5506	83	9801	-5589	114	9915	-5703	65	9980	-5768	262	2927			Too Shallow	0	0	0	Wildcat
Mobil Oil Corporation	State "GG"		1	10-11S-34E	1980 FSL	1980 FEL	33.3784679	-103.49651	30-025-22151	4156	9866	-5710	86	9952	-5796	105	10057	-5901	62	10119	-5963	253	46625			SWD	0	0	0	Sand Springs
Hill & Meeker	State 11		1	11-11S-34E	1650 FNL	2310 FEL	33.38300	-103.47989		4154	9940	-5786	125	10065	-5911	100	10165	-6011	61	10226	-6072	286	46659			Too Deep	0	0	0	Sand Springs
Manzano Oil	Snake Eyes State		1	6-11S-35E	946 FNL	660 FEL	33.39386	-103.44018	30-025-22726	4163	10022	-5859	90	10112	-5949	96	10208	-6045	79	10287	-6124	265	46764			Too Shallow	0	0	0	Unnamed
DeKalb Agricultural Asso	State A-1		1	26-11S-32E	1980 FNL	1980 FWL	33.33870	-103.68980		4365	8865	-4500	90	8955	-4590	94	9049	-4684	71	9120	-4755	255	46617			P & A	0	0	0	Moore
The Texas Company	Moore		1	25-11S-32E	660 FNL	660 FWL	33.3423693	-103.67753	30-025-00069	4341	8749	-4408	83	8832	-4491	66	8898	-4557	83	8981	-4640	232	15905			Too Shallow	0	0	0	Moore
Stoltz & Company, Inc. &	Peggy Com		1	29-11S-33E	1980 FNL	660 FWL	33.33876	-103.64243		4313	8869	-4556	80	8949	-4636	83	9032	-4719	96	9128	-4815	259	46696			Too Deep	0	0	0	Bagley
Stoltz	Kelsay		1	28-11S-33E	660 FSL	660 FWL	33.33147	-103.62507		4290	8983	-4693	90	9073	-4783	112	9185	-4895	73	9258	-4968	275	2923			Too Deep	0	0	0	Bagley
Midwest Oil	NM "O" State		1	26-11S-33E	660 FNL	510 FEL	33.3422605	-103.57769	30-025-22407	4237	9216	-4979	85	9301	-5064	59	9360	-5123	58	9418	-5181	202	42093			Too Deep	0	0	0	Bagley
Felmont Oil Corp.	Felmont Skelly		1	28-11S-34E	660 FSL	760 FEL	33.33133	-103.50919		4182	9910	-5728	85	9995	-5813	75	10070	-5888	72	10142	-5960	232	46250			P & A	0	0	0	Wildcat
Cabot Carbon Company	State	1H		30-11S-35E	1980 FNL	1980 FEL	33.33850	-103.44444		4161	9920	-5759	121	10041	-5880	97	10138	-5977	61	10199	-6038	279	2934			P & A	0	0	0	Wildcat
Elk Oil Company	Conners State		1	10-12S-32E	660 FNL	660 FEL	33.29873	-103.69872		4396	8905	-4509	67	8972	-4576	143	9115	-4719	54	9169	-4773	264	46740			D & A	0	0	0	Unnamed
The Texas Company	State of NM "BH"		3	11-12S-32E	1980 FNL	663 FWL	33.29509	-103.69437		4392	8834	-4442	58	8892	-4500	142	9034	-4642	59	9093	-4701	259	47303			Too Deep	0	0	0	Caprock
Meadco Prop. Ltd.	Shell State "H"		1	8-12S-33E	554 FNL	554 FEL	33.29905	-103.62919		4260	8910	-4650	133	9043	-4783	125	9168	-4908	51	9219	-4959	309	37376			Too Deep	0	0	0	Bagley
Major, Griebel & Forster	Huber		1	9-12S-33E	510 FNL	660 FEL	33.29923	-103.61237	30-025-23651	4265	9007	-4742	105	9112	-4847	125	9237	-4972	81	9318	-5053	311	37377			Too Deep	0	0	0	Bagley
Western States Producin	Simons		1	11-12S-33E	1980 FNL	510 FWL	33.2951227	-103.59158	30-025-23823	4255	8884	-4629	94	8978	-4723	135	9113	-4858	101	9214	-4959	330	21972			Too Deep	0	0	0	Bagley
Western States	Smelting State		1	9-12S-34E	1980 FNL	1980 FWL	33.29505	-103.51759		4190	9486	-5296	70	9556	-5366	140	9696	-5506	92	9788	-5598	302	2875			Too Deep	0	0	0	Bagley
Trice Production Compar	Four Lakes State of		1	11-12S-34E	660 FNL	1980 FWL	33.29877	-103.48304		4164	9729	-5565	82	9811	-5647	133	9944	-5780	85	10029	-5865	300	2876			P & A	0	0	0	Unnamed
Ashmun & Hilliard Trust	Hassie Hunt-State "		1	26-12S-32E	1980 FSL	1980 FWL	33.24743	-103.68981		4342	8467	-4125	103	8570	-4228	105	8675	-4333	85	8760	-4418	293	46825			D & A	0	0	0	Wildcat
Skelly Oil Co.	Hobbs Y		1	29-12S-34E	1980 FSL	1980 FEL	33.24759	-103.53033		4198	9958	-5760	51	10009	-5811	87	10096	-5898	55	10151	-5953	193	21974			D & A	0	0	0	Unnamed
Midwest Oil	State	1-A		28-12S-34E	660 FNL	660 FEL	33.25483	-103.50882		4180	9950	-5770	94	10044	-5864	104	10148	-5968	48	10196	-6016	246	37936			P & A	0	0	0	Wildcat
Tennessee Gas Transmis	State		1	27-12S-34E	1980 FNL	2310 FWL	33.25126	-103.49907		4172	9930	-5758	80	10010	-5838	123	10133	-5961	51	10184	-6012	254	40311			P & A	0	0	0	Ranger Lake
Flag Redfern Oil Co.	Huber State		1	33-12S-35E	1980 FSL	1980 FWL	33.2334332	-103.41049	30-025-28902	4084	10376	-6292	46	10422	-6338	100	10522	-6438	50	10572	-6488	196	46802			D & A	0	0	0	Wildcat
North Central Oil	State "14"		1	14-13S-32E	1981 FSL	2319 FWL	33.18968	-103.68877	30-025-31761	4326	9417	-5091	80	9497	-5171	129	9626	-5300	84	9710	-5384	293	45532			D & A	0	0	0	Wildcat
Yates Petroleum	Bass "ON" State		2	18-13S-33E	1980 FNL	1980 FWL	33.19333	-103.65530		4304	9562	-5258	100	9662	-5358	84	9746	-5442	63	9809	-5505	247	37942			D & A	0	0	0	Baum
Apache Corporation	Cities Servics Same		1	11-13S-33E	660 FSL	660 FEL	33.20054	-103.57764		4238	9759	-5521	67	9826	-5588	80	9906	-5668	93	9999	-5761	240	46194			D & A	0	0	0	Wildcat
Ashmun & Hilliard	Clarence Church		1	17-13S-34E	660 FSL	660 FEL	33.18609	-103.52598		4170	9981	-5811	84	10065	-5895	86	10151	-5981	78	10229	-6059	248	46392			D & A	0	0	0	Wildcat
Phillips Petr. Co.	Tatum "E"		1	15-13S-34E	660 FNL	1980 FEL	33.19699	-103.49588		4166	10248	-6082	58	10306	-6140	73	10379	-6213	64	10443	-6277	195	46391			D & A	0	0	0	Wildcat
Humble Oil & Refg. Co.	Ethel Key		1	23-13S-34E	1980 FNL	1980 FWL	33.17893	-103.48288		4144	10246	-6102	64	10310	-6166	75	10385	-6241	63	10448	-6304	202	3047			P & A	0	0	0	Wildcat
R.K. Petroleum	State		1	27-13S-32E	660 FNL	1980 FEL	33.16783	-103.70282		4328	9360	-5032	100	9460	-5132	151	9611	-5283	69	9680	-5352	320	46791			Too Deep	0	0	0	Wildcat
Delaware-Apache Corp.	State "30"		1	30-13S-33E	1980 FNL	660 FEL	33.16415	-103.64700		4286	9588	-5302	111	9699	-5413	71	9770	-5484	41	9811	-5525	223	46397			D & A	0	0	0	Wildcat

Coastal States Gas Prod	Chambers	2	29-13S-33E	660 FNL	660 FWL	33.16776	-103.64264		4277	9582	-5305	89	9671	-5394	79	9750	-5473	49	9799	-5522	217	46396							D & A	0	0	0	Lazy-J	
Cactus Drilling Corp. et a	Smelters State	1	30-13S-34E	660 FSL	660 FEL	33.15692	-103.54321		4179	10286	-6107	94	10380	-6201	70	10450	-6271	78	10528	-6349	242	46406							D & A	0	0	0	Wildcat	
Midwest Oil Corp.	Harris State	1	29-13S-34E	660 FSL	1980 FWL	33.15693	-103.53458		4173	10280	-6107	90	10370	-6197	80	10450	-6277	68	10518	-6345	238	44549							SWD	0	0	0	Nonombre	
Jack McClellan	Dye	1	28-13S-34E	660 FSL	660 FEL	33.15687	-103.50867		4158	10342	-6184	89	10431	-6273	94	10525	-6367	75	10600	-6442	258	22717	10326	10450	x	x			150 BO+1 BW	0			Nonombre	
Amoco Production	State "FO"	2	32-13S-34E	660 FNL	1980 FWL	33.15330	-103.53457	30-025-21628	4172	10253	-6081	96	10349	-6177	120	10469	-6297	70	10539	-6367	286	21633	10698	10717					Too Deep	0	0	0	Nonombre	
Western Oil Producers	State "C"	1	31-13S-34E	1980 FSL	660 FEL	33.14601	-103.54314		4175	10318	-6143	89	10407	-6232	84	10491	-6316	49	10540	-6365	222	21632							D & A	0	0	0	Wildcat	
Ensign Operating	Key 20	1	20-13S-35E	2495 FNL	837 FEL	33.17758	-103.42319	30-025-36140	4097	10358	-6261	59	10417	-6320	107	10524	-6427	67	10591	-6494	233	42389							Too Deep	0	0	0	Wildcat	
Sharples Oil Corp.	Seth Alston	1	17-13S-35E	560 FSL	660 FWL	33.18591	-103.43565		4114	10305	-6191	66	10371	-6257	110	10481	-6367	69	10550	-6436	245	10656							P & A	0	0	0	Wildcat	
Union Texas Petroleum C	Shell State	1	6-13S-35E	1980 FNL	660 FWL	33.22233	-103.45278	30-025-23722	4130	10208	-6078	70	10278	-6148	95	10373	-6243	61	10434	-6304	226	46409							Too Deep	0	0	0	Wildcat	
Goridge Corp.	Livermore State "G"	9	31-12S-32E	467 FNL	1787 FWL	33.24083	-103.75975	30-025-21249	4396	8998	-4602	90	9088	-4692	106	9194	-4798	48	9242	-4846	244	46827	8701	8708					Too Shallow	0	0	0	Wildcat	
The Texas Company	State "BA"	1	22-12S-32E	660 FNL	660 FEL	33.26978	-103.69866		4357	8399	-4042	101	8500	-4143	111	8611	-4254	83	8694	-4337	295	153							P & A	0	0	0	Wildcat	
XPLOR Company	Cleveland	1	23-12S-32E	1650 FNL	2310 FEL	33.26697	-103.68658		4343	8475	-4132	70	8545	-4202	66	8611	-4268	85	8696	-4353	221	2867							P & A	0	0	0	Caprock Queen	
Lawton Oil Corp.	State	4	14-13S-33E	660 FNL	660 FWL	33.19694	-103.59058		4258	9607	-5349	120	9727	-5469	112	9839	-5581	55	9894	-5636	287	32727							P & A	0	0	0	Wildcat	
Cities Service Comp.	Federal "Z"	1	22-13S-34E	1980 FNL	660 FEL	33.17894	-103.49151	30-025-28489	4153	10379	-6226	67	10446	-6293	96	10542	-6389	54	10596	-6443	217	31975							D & A	0	0	0	Wildcat	
CW Trainer	Betenbough	1	20-13S-34E	660 FSL	1980 FWL	33.17141	-103.53460		4181	10242	-6061	98	10340	-6159	95	10435	-6254	81	10516	-6335	274	3046							P & A	0	0	0	Wildcat	
Magnolia Petr. Co.	Four Lakes Unit	1	15-10S-34E	660 FSL	660 FEL	33.44205	-103.44491		4209	9605	-5396	88	9693	-5484	178	9871	-5662	74	9945	-5736	340	2822							P & A	0	0	0	Wildcat	
Midwest Oil Corp.	State of NM "A"	1	14-10S-33E	660 FNL	660 FWL	33.45215	-103.54471	30-025-21911	4218	9430	-5212	102	9532	-5314	119	9651	-5433	73	9724	-5506	294	40270	9657	9665			x		340 BO+100 BW	0			Middle Lane	XXXX
Haskins & Knickerbocker	Lane Ranch	1	4-10S-33E	1980 FSL	660 FEL	33.47380	-103.56616		4271	9380	-5109	87	9467	-5196	81	9548	-5277	65	9613	-5342	233	2815							P & A	0	0	0	Wildcat	
Humble Oil & Refg. Co.	NM State "CA"	1	35-10S-33E	500 FNL	500 FWL	33.40924	-103.54530		4215	9502	-5287	95	9597	-5382	83	9680	-5465	73	9753	-5538	251	40250							D & A	0	0	0	Wildcat	
Humble Oil & Refg. Co.	NM State "BR"	1	36-10S-34E	330 FSL	1980 FEL	33.39752	-103.41456		4132	9800	-5668	136	9936	-5804	122	10058	-5926	72	10130	-5998	330	2824							P & A	0	0	0	Wildcat	
BTA Oil	Clair	1	3-10S-32E	660 FNL	1980 FEL	33.48058	-103.65720		4333	9292	-4959	105	9397	-5064	113	9510	-5177	61	9571	-5238	279	2803							P & A	0	0	0	Wildcat	
Cities Service Oil Comp.	State "BL"	1	14-10S-32E	1980 FNL	660 FWL	33.44817	-103.64902		4347	9181	-4834	99	9280	-4933	74	9354	-5007	67	9421	-5074	240	14744							Too Shallow	0	0	0	San Andres	
Sunray DX Oil Co.	NM State "AP"	1	17-10S-34E	1650 FSL	990 FEL	33.44480	-103.48054		4231	9748	-5517	80	9828	-5597	132	9960	-5729	52	10012	-5781	264	49691	9962	9966			x		P & A	0	0	0	Wildcat	
Britton Mgmt.	Templo (owwo)	1	34-10S-32E	1980 FSL	1980 FWL	33.40113	-103.66226		4339	9312	-4973	84	9396	-5057	123	9519	-5180	88	9607	-5268	295	2812							D & A	0	0	0	Wildcat	
Cities Production Comp.	State "AD"	3	22-10S-32E	330 FSL	990 FEL	33.42537	-103.65460		4340	9241	-4901	62	9303	-4963	147	9450	-5110	94	9544	-5204	303	57							Too Shallow	0	0	0	Mescalero	
Fundamental Oil Corp.	State D	1	36-10S-32E	1980 FSL	1980 FEL	33.40130	-103.62300		4310	9329	-5019	75	9404	-5094	79	9483	-5173	58	9541	-5231	212	21302							D & A	0	0	0	Cuerno Largo	
Dwight Tipton	State DX	1	33-10S-32E	1980 FNL	1980 FWL	33.40445	-103.67961		4355	9310	-4955	82	9392	-5037	76	9468	-5113	58	9526	-5171	216	35754							Too Shallow	0	0	0	Wildcat	
Cabot Carbon Company	State D	1	31-10S-33E	1980 FSL	660 FEL	33.40128	-103.60116		4249	9319	-5070	81	9400	-5151	85	9485	-5236	61	9546	-5297	227	2820							P & A	0	0	0	Wildcat	
Major, Griebel & Forster	Sunray State Y	1	19-10S-33E	1980 FSL	990 FWL	33.42997	-103.61311		4212	9290	-5078	93	9383	-5171	94	9477	-5265	44	9521	-5309	231	40242							D & A	0	0	0	Wildcat	
Cameron Oil	Bogle Farms	1	15-11S-34E	600 FSL	600 FEL	33.36019	-103.49145		4169	9951	-5782	111	10062	-5893	108	10170	-6001	79	10249	-6080	298	2929							P & A	0	0	0	Wildcat	
Sunset International Petr	Mobil State	1	3-11S-34E	660 FSL	1980 FWL	33.38947	-103.50038		4177	9981	-5804	113	10094	-5917	96	10190	-6013	90	10280	-6103	299	23754							D & A	0	0	0	Wildcat	
Petroleum Reserve	Tenneco State	1	2-11S-34E	330 FSL	660 FEL	33.38846	-103.47450	30-025-25762	4149	9931	-5782	119	10050	-5901	100	10150	-6001	62	10212	-6063	281	23972							Too Deep	0	0	0	Sand Springs	
French Jr.	Bogle	1	16-11S-34E	660 FSL	660 FWL	33.36042	-103.52201		4197	9618	-5421	85	9703	-5506	109	9812	-5615	75	9887	-5690	269	10726							P & A	0	0	0	Wildcat	
Yates Petroleum	Lagarto State Unit	1	18-11S-35E	660 FSL	1839 FWL	33.36040	-103.44881	30-025-30676	4162	10032	-5870	138	10170	-6008	68	10238	-6076	88	10326	-6164	294	41330							P & A	0	0	0	Wildcat	
Lonestar Producing Co.	New Mexico "81" St	1	19-11S-35E	1980 FSL	1980 FWL	33.34938	-103.44822		4150	9915	-5765	65	9980	-5830	97	10077	-5927	64	10141	-5991	226	46766							D & A	0	0	0	Wildcat	
Read & Stephens	State "F"	1	13-11S-32E	660 FNL	510 FEL	33.37132	-103.66351		4483	8902	-4419	98	9000	-4517	102	9102	-4619	54	9156	-4673	254	21960							D & A	0	0	0	North Bagley	
Charles B. Read	Shell State	3	18-11S-33E	660 FNL	2097 FWL	33.37141	-103.65498		4330	8874	-4544	75	8949	-4619	99	9048	-4718	84	9132	-4802	258	48729							Too Deep	0	0	0	North Bagley	
Stoltz & Company	Dolly	1	17-11S-33E	1980 FSL	1980 FEL	33.36409	-103.63385		4320	9160	-4840	146	9306	-4986	119	9425	-5105	87	9512	-5192	352	37919	9780	10147					Too Deep	0	0	0	North Bagley	
Southland Royalty Co.	Farrar B	1	13-11S-33E	766 FSL	2086 FEL	33.36069	-103.56509	30-025-21749	4223	9130	-4907	87	9217	-4994	101	9318	-5095	42	9360	-5137	230	46326	9758	9774					Too Deep	0	0	0	Inbe	
Stoltz & Company	Bess	1	20-11S-33E	660 FNL	1980 FEL	33.35683	-103.63388		4308	8799	-4491	78	8877	-4569	83	8960	-4652	91	9051	-4743	252	23755	9308	9311					Too Deep	0	0	0	North Bagley	1984
TF Hodge	State "W"	1	31-11S-34E	660 FSL	1846 FWL	33.31686	-103.55214		4224	9723	-5499	101	9824	-5600	76	9900	-5676	55	9955	-5731	232	23969							D & A	0	0	0	Wildcat	
Ralph Lowe	Amerada State	1	32-11S-34E	660 FNL	660 FWL	33.32770	-103.53911		4207	9694	-5487	87	9781	-5574	89	9870	-5663	85	9955	-5748	261	23751							D & A	0	0	0	Wildcat	
JM Huber Corp.	Gulf State A	1	23-11S-34E	660 FSL	1980 FEL	33.34586	-103.47860	30-025-20698	4157	9921	-5764	95	10016	-5859	73	10089	-5932	61	10150	-5993	229	46660							D & A	0	0	0	Wildcat	
Humble Oil	State X	1	31-11S-35E	660 FNL	1980 FEL	33.32766	-103.44445		4155	9905	-5750	72	9977	-5822	139	10116	-5961	72	10188	-6033	283	32548							P & A	0	0	0	Wildcat	
Southwest Production Cc	Bogle State	1	32-11S-35E	660 FSL	660 FWL	33.31691	-103.43581		4174	9919	-5745	91	10010	-5836	129	10139	-5965	61	10200	-6026	281	21969							D & A	0	0	0	Wildcat	
Southern Petr. Exploratio	SPX Danglade Stat	1	3-12S-34E	660 FSL	660 FEL	33.30241	-103.49166		4174	9506	-5332	99	9605	-5431	135	9740	-5566	101	9841	-5667	335	2874							P & A	0	0	0	Four Lakes	
Austral Oil Expl. Co. Inc.	State E 208	1	6-12S-35E	660 FSL	1980 FEL	33.30243	-103.44434		4144	9670	-5526	124	9794	-5650	156	9950	-5806	90	10040	-5896	370	2951							D & A	0	0	0	Wildcat	
Elk Oil Company	Moore	1	36-11S-32E	660 FSL	1980 FWL	33.31684	-103.67255		4340	8860	-4520	90	8950	-4610	70	9020	-4680	74	9094	-4754	234	37916							D & A	0	0	0	Wildcat	
Amerada Petr. Corp.	CW Robinson	1	23-11S-32E	660 FNL	660 FEL	33.35685	-103.68105		4354	8967	-4613	116	9083	-4729	124	9207	-4853	54	9261	-4907	294	75							Too Deep	0	0	0	Moore (Dev)	
Amerada Petr. Corp.	State "MA"	1	24-11S-32E	660 FSL	660 FWL	33.34592	-103.67677		4341	8815	-4474	47	8862	-4521	63	8925	-4584	83	9008	-4667	193	77							Too Deep	0	0	0	Moore (Dev)	
HS Moss	HS Moss State	1	32-11S-33E	660 FSL	660 FWL	33.31685	-103.64234		4302	8860	-4558	84	8944	-4642	86	9030	-4728	106	9136	-4834	276	32545							P & A	0	0	0	Wildcat	
Amerada Petr. Corp.	State BTD	3	35-11S-33E	660 FSL	660 FEL	33.31701	-103.57761		4247	8906	-4659	124	9030	-4783	132	9162	-4915	102	9264	-5017	358	15907							Too Deep	0	0	0	Bagley (Sil-Dev)	
Sunray Mid-Continent	NM State J	1	1-12S-33E	330 FNL	330 FWL	33.31428	-103.51435	30-025-01024	4242	9364	-5122	74	9438	-5196	132	9570	-5328	59	9629	-5387	265	2869							P & A	0	0	0	Wildcat	
Meadco	Shell State "A"	1	4-12S-33E	1980 FSL	1980 FWL	33.30604	-103.62086		4277	9011	-4734	97	9108	-4831	89	9197	-4920	89	9286	-5009	275	47504							P & A	0	0	0	Bagley Penn	
T & P Coal & Oil	State "B"	1	2-12S-33E	1980 FNL	660 FEL	33.30975	-103.57758		4240	8866	-4626	119	8985	-4745	133	9118	-4878	91	9209	-4969	343	2870							Too Deep	0	0	0	Bagley Dev	
Western States Producin	Cabot State	1	4-12S-34E	1755 FSL	1980 FEL	33.30531	-103.51331		4187	9520	-5333	99	9619	-5432	111	9730	-5543	84	9814	-5627	294	40786							SWD	0	0	0	Wildcat	
Coastal States Gas Prod	US Smelting & Refi	1	5-12S-34E	1980 FNL	1980 FWL	33.30951	-103.53485		4191	9504	-5313	126	9630	-5439	98	9728	-5537	84	9812	-5621	308	21249							D & A	0	0	0	Wildcat	
Tom Thagard	State "B"	2	15-12S-34E	1980 FNL	660 FEL	33.28056	-103.49162		4168	9980	-5812	67	10047	-5879	103	10150	-5982	76	10226	-6058	246	2879							P & A	0	0	0	Ranger Lake	
Amerada Petr. Corp.	State WR "A"	1	35-12S-34E	660 FNL	660 FWL	33.24036	-103.48705	30-025-22496	4160	10019	-5859	101	10120	-5960	117	10237	-6077	68	10305	-6145	286	2896	10237	10305			x		215 BO	0			Ranger Lake	
Penroc Oil	State RLB	1	33-12S-34E	660 FSL	660 FEL	33.22962	-103.50878		4182	10005	-5823	45	10050	-5868	101	10151	-5969	54	10205	-6023	200	6870							P & A	0	0	0	Ranger Lake	
Texas Company	State of NM "BF"	1	6-12S-32E	1980 FSL	1980 FEL	33.30602	-103.75468		4428	8970	-4542	59	9029	-4601	141	9170	-4742	52	9222	-4794	252	32555							P & A	0	0	0	Wildcat	
Yates Petroleum	Winter State Unit	1	3-12S-32E	660 FSL	1933 FEL	33.30238	-103.70289	30-025-00089	4417	8918	-4501	74	8992	-4575	184	9176	-4759	68	9244	-4827	326	119							P & A	0	0	0	Caprock	
Texas Company	State B.F.	1	2-12S-32E	676 FNL	660 FWL	33.31329	-103.69428		4373	8915	-4542	82	8997	-4624	123	9120	-4747	74	9194	-4821	279	15912							P & A	0	0	0	E. Caprock	
Ronadero Company	Ronalto	2	14-12S-32E	330 FSL	2310 FEL	33.27241	-103.68658	30-025-29376	4349	8454	-4105	71	8525	-4176	85	8610	-4261	101	8711	-4362	257	40117							D & A	0	0	0	Wildcat	
Yates Petroleum	Midwest Hightower	1	31-12S-33E	660 FSL	660 FWL	33.22952	-103.65955	30-025-23359	4298	9400	-5102	80	9480	-5182	79	9559	-5261	78	9637	-5339	237	49052							D & A	0	0	0	Wildcat	
Adobe Oil Co.	Moralo State	1	19-12S-33E	1980 FSL	660 FEL	33.26205	-103.64658	30-025-25535	4312	9252	-4940	73	9325	-5013	60	9385	-5073	69	9454	-5142	202	46798							D & A	0	0	0	Wildcat	
Pubco Petroleum Corp.	State "AN"	38	20-12S-33E	660 FSL	660 FEL	33.25845	-103.62921	30-025-22633	4303	9243	-4940	86	9329	-5026	77	9406	-5103	62	9468	-5165	225	37379							D & A	0	0	0	Wildcat	
Amerada Petr. Corp.	State BTE	1	23-12S-33E	660 FSL	1980 FWL	33.25843	-103.58626		4253	8921	-4668	105	9026	-4773	86	9112	-4859	108	9220	-4967	299	14784							Too Deep	0	0	0	Hightower	
Phillips Petr. Co.	Signal	1	19-12S-34E	660 FSL	1903 FWL	33.25841	-103.55196		4219	9895	-5676	115	10010	-5791	74	10084	-5865	68	10152	-5933	257	2882							P & A	0	0	0	Hightower	
Murphy H Baxter	Lowe State	1	20-12S-34E	660 FSL	1980 FEL	33.25840	-103.53044		4195	9933	-5738	76	10009	-5814	98	10107	-5912	52	10159	-5964	226	10640							P & A	0	0	0	Hightower	
CH Juni	Cabot-State	1	29-13S-32E	1980 FNL	660 FEL	33.16436	-103.73309	30-025-24450	4356	8938	-4582	70	9008	-4652	132	9140	-4784	97	9237	-4881	299	46842							Too Deep	0	0	0	Wildcat	
Texas & Pacific Coal & O	Dry Lake Unit	1	33-13S-32E	660 FSL	1980 FEL	33.14236	-103.72000		4360	9198	-4838	149	9347	-4987	114	9461	-5101	79	9540	-5180	342	23403							P & A	0	0	0	Wildcat	
ML Brown	State "BD"	1	34-13S-32E	660 FSL	1980 FWL	33.14234	-103.70706	30-025-00320	4340	9371	-5031	69	9440	-5100	149	9589	-5249	100	9689	-5349	318	3040							P & A	0	0	0	Wildcat	
Yates Petroleum	Lazy Tree State Uni	1	12-13S-32E	660 FNL	660 FEL	33.21132	-103.66394	30-025-30149	4325	9497	-5172	58	9555	-5230	108	9663	-5338	72	9735	-5410	238	42228							D & A	0	0	0	Wildcat	
Yates Petroleum	Lebough 5 State	1	5-13S-33E	1980 FSL	1980 FWL	33.21862	-103.63798	30-025-20373	4283	9396	-5113	75	9471	-5188	115	9586	-5303	63	9649	-5366	253	46381							D & A	0	0	0	Wildcat	
Pan American Petr. Corp	State "DN"	1	19-13S-33E	660 FNL	1980 FWL	33.18239	-103.65526		4294	9647	-5353	61	9708	-5414	94	9802	-5508					48190	9670	9779	x	x			185 BO+77 BW	0	0	0	N Baum	1975
Union Texas Petroleum C	State "23"	1	23-13S-33E	1980 FNL	660 FEL	33.17877	-103.57767		4223	9660	-5437	84	9744	-5521	69	9813	-5590	57	9870	-5647	210	46389							D & A	0	0	0	Lazy-J	
TOTALS																														**9957364**	**21741936**	**15042596**		

Operator	Lease Name	Well Number	API Number	Township (South)	Range (East)	Section	Loc in section	Latitude	Longitude	Elevation KB	Wolfcamp shale top	Wolfcamp shale subsea	Mississippian top	Mississippian subsea	Wolfcamp Mississippian thickness	Upper Penn production	Comments
Yates Petroleum	Divide Federal JW	1	30-015-22643	17	24	4	1980FS/1980FW	32.86267	-104.59554	3765	4814	-1049	6974	-3209	2160	0	
Beard Oil	Hagstrom	1	30-015-22360	17	24	8	1983FS/1992FW	32.84814	-104.61276	3818	4818	-1000	7120	-3302	2302	0	
Socony Mobil Oil	Federal	1		17	24	9	1980 FS/1980 FW	32.84806	-104.59555	3785	4852	-1067	7130	-3345	2278	-	
Yates Petroleum	Niles KA	1	30-015-22712	17	24	24	660 FS/1980 FW	32.81577	-104.54355	3676	5214	-1538	7854	-4178	2640	0	poor logs
Yates Petroleum	Federal GR	1	30-015-21950	17	24	25	2050FN/660FW	32.80835	-104.54784	3708	5208	-1500	7942	-4234	2734	+	
Pubco Petroleum	Cass North	1	30-015-20570	17	24	29	660FS/1980FE	32.80098	-104.60830	3834	4900	-1066	7684	-3850	2784	-	
Kaiser Francis	Catclaw State	1	30-015-22707	17	24	31	1980FN/1980FE	32.79369	-104.62548	3901	5006	-1105	7650	-3749	2644	0	
Yates Petroleum	Richard Knob AEX State	1	30-015-25848	17	24	34	1980FN/1980FE	32.79385	-104.57365	3764	5154	-1390	7960	-4196	2806	+	
Yates Petroleum	State DF	1		17	24	35	660FN/660FW	32.79757	-104.56507	3734	5164	-1430	7984	-4250	2820	+	
Nearburg	Hagaman	1	30-015-30660	17	25	3	300 FN/300 FE	32.87099	-104.46507	3527	5448	-1921	7880	-4353	2432	0	
Yates Petroleum	Eagle Federal	1	30-015-20583	17	25	8	1980 FN/1980 FE	32.85186	-104.50517	3587	5224	-1637	7714	-4127	2490	0	
Yates Petroleum	Artesia Airport CF	2	30-015-21384	17	25	10	1650 FS/860 FE	32.84695	-104.46703	3523	5382	-1859	7970	-4447	2588	-	
Yates Petroleum	Artesia Airport CF	1	30-015-20519	17	25	11	330 FS/990 FW	32.84331	-104.46101	3511	5396	-1885	7930	-4419	2534	-	
Yates Petroleum	Achen Frey DM	3	30-015-21194	17	25	13	660 FS/1980 FW	32.82981	-104.44031	3452	5470	-2018	8078	-4626	2608	-	
Yates Petroleum	Federal BZ	12	30-015-21625	17	25	21	1980FS/1980FW	32.81907	-104.49236	3587	5372	-1785	8050	-4463	2678	+	
Yates Petroleum	Federales BO	10	30-015-24101	17	25	22	990 FN/1980 FE	32.82528	-104.47069	3529	5412	-1883	8116	-4587	2704	0	
Yates	Mitchell IN	2		17	25	23	2030 FS/660 FE	32.81908	-104.44897	3476	5464	-1988	8048	-4572	2584	0	
Western Oil	Flint	2	30-015-21559	17	25	25	660 FS/2310 FW	32.80090	-104.43944	3483	5522	-2039	8430	-4947	2908	0	
Yates Petroleum	Federal CR	1	30-015-20895	17	25	29	660 FS/660 FW	32.80114	-104.51345	3612	5354	-1742	8064	-4452	2710	+	
Yates Petroleum	Federal EF	2	30-015-23210	17	25	31	1980 FS/660 FW	32.79002	-104.53062	3646	5294	-1648	8056	-4410	2762	+	
Yates Petroleum	Powell Kissinger BS	2	30-015-25183	17	25	33	990FS/1650FE	32.78726	-104.48693	3566	5468	-1902	8440	-4874	2972	+	
Yates Petroleum	Powell DG	1		17	25	35	660 FS/1980 FE	32.78627	-104.45345	3490	5528	-2038	8386	-4896	2858	+	
Yates Petroleum	Arco EC State	1	30-015-21472	17	25	36	660 FN/2310 FE	32.79725	-104.43714	3453	5556	-2103	8480	-5027	2924	+	
Yates Petroleum	Haldeman DA	1	30-015-21046	17	26	3	660 FS/2040 FW	32.85891	-104.37148	3351	5520	-2169	8210	-4859	2690	0	
Yates Petroleum Corp.	Coll "LD" Com	1	30-015-23352	17	26	9	660FSL/660FEL	32.84434	-104.38001	3364	5668	-2304	8374	-5010	2706	0	
Atlantic Richfield	H.W. Hornbaker	1		17	26	20	510 FS/1680 FE	32.81495	-104.40054	3403	5668	-2265	8416	-5013	2748	0	
Yates Petroleum	Siegenthaller IS	1	30-015-22329	17	26	21	1980FS/660FE	32.81897	-104.37990	3375	5708	-2333	8460	-5085	2752	-	
Yates Petroleum	Berry EE	1	30-015-21481	17	26	23	990FS/990FW	32.81604	-104.35734	3335	5768	-2433	8674	-5339	2906	0	
Sun	Farmer Glen	1	30-015-22160	17	26	26	1980 FS/1980 FW	32.80421	-104.35419	3305	5804	-2499	8740	-5435	2936	+	
Hanson Oil	Big Buck Pounds	1	30-015-21103	17	26	27	1980 FS/660 FE	32.80424	-104.36278	3336	5778	-2442	8736	-5400	2958	0	
Maddox Energy	Martin	1	30-015-22046	17	26	29	1980 FS/660 FW	32.80430	-104.41016	3415	5620	-2205	8460	-5045	2840	0	
Yates Petroleum	Patterson EL	2	30-015-22760	17	26	31	660 FS/2310 FW	32.78592	-104.42207	3422	5632	-2210	8550	-5128	2918	0	
Yates Petroleum	Kennedy JQ	1	30-015-22548	17	26	33	2510FN/660FE	32.79195	-104.37994	3352	5750	-2398	8676	-5324	2926	0	
David Fasken	Majorie Naylor	1	30-015-21496	17	26	35	990 FS/1650 FE	32.78669	-104.34882	3303	5884	-2581	8868	-5565	2984	0	
Yates Petroleum	Dog Canyon Draw UP	1	30-015-24167	17	27	2	1500FS/660FE	32.85956	-104.24232	3508	6514	-3006	9430	-5922	2916	0	
OXY USA	LD 4 Federal	1	30-015-29865	17	27	4	660FS/1980FE	32.85823	-104.28102	3419	6184	-2765	9204	-5785	3020	0	
Yates	Concho ACT State	1	30-015-30659	17	27	8	1650FN/680FE	32.85205	-104.29398	3379	6070	-2691	8930	-5551	2860	0	
Concho Resources	Herman 10 Federal	1	30-015-30991	17	27	10	990 FS/660 FW	32.84378	-104.27232	3412	6216	-2804	absent			0	
Amoco	Federal CX	1	30-015-24025	17	27	12	660FN/1650FE	32.85365	-104.22887	3551	6554	-3003	9804	-6253	3250	0	
Bell	Federal	1		17	27	17	2310 FS/1880 FE	32.83332	-104.29768	3365	6134	-2769	9018	-5653	2884	-	
Yates Petroleum	Kepple ZN	1	30-015-24924	17	27	18	660FS/1980FE	32.82913	-104.31507	3367	6038	-2671	8924	-5557	2886	-	
Nearburg	Logan Draw 19 Federal	1	30-015-31220	17	27	19	810 FS/740 FE	32.81479	-104.31088	3358	6070	-2712	9040	-5682	2970	-	
Mesa Petroleum	Peterson Federal	1	30-015-23008	17	27	20	1980 FN/1980 FE	32.82153	-104.29787	3393	6176	-2783	9128	-5735	2952	-	
Maralo	Berry Federal	2	30-015-21443	17	27	22	660 FS/1980 FE	32.81408	-104.26392	3545	6460	-2915	9550	-6005	3090	0	
Ralph Lowe	Federal Berry	1		17	27	23	1980 FN/1980 FW	32.82119	-104.25092	3545	6504	-2959	9600	-6055	3096	0	
Mesa Petroleum	Berry Federal	1	30-015-22691	17	27	28	1980FN/660FW	32.80698	-104.28897	3416	6278	-2862	9320	-5904	3042	+	
Murchison O&G	Potter Federal	1	30-015-22144-000	17	27	29	860 FN/1985 FE	32.81009	-104.29767	3383	6164	-2781	9114	-5731	2950	+	
Yates Petroleum	Fasken Exxon AOF Federal	1	30-015-21595-000	17	27	31	1980 FS/1980 FE	32.78927	-104.31499	3370	6090	-2720	9242	-5872	3152	0	
Carper Sivley	Magruder	15		17	27	35	1650 FS/2310 FW	32.78743	-104.24975	3645	6648	-3003	9822	-6177	3174	0	
Swestern Energy	No Bluff State	1	30-015-30907	17	27	36	660 FN/860 FW	32.79577	-104.23759	3605	6706	-3101	9776	-6171	3070	0	
Murchison O&G	High Mesa State	1	30-015-31720	17	28	2	1320 FS/1000 FE	32.86084	-104.14120	3601	7038	-3437	10126	-6525	3088	0	
Enron O&G	Amtrack State	1	30-015-30758	17	28	4	660 FS/660 FE	32.85751	-104.17434	3545	6786	-3241	9828	-6283	3042	0	
Harvey E. Yates	Gates Federal Deep	1		17	28	6	660 FS/660 FE	32.85737	-104.20827	3541	6674	-3133	9572	-6031	2898	0	
EOG Resources	Starbuck 19 Federal	1	30-015-31327-000	17	28	19	1140 FN/1650 FW	32.82323	-104.21782	3597	6720	-3123	9768	-6171	3048	0	
Kersey	Red Lake Premier Sand	5		17	28	20	1650 FS/1650 FE	32.81682	-104.19423	3630	6882	-3252	10100	-6470	3218	0	
Yates Petroleum	Lucas Store KT State	1	30-015-22893	17	28	22	1980FN/1980FE	32.82130	-104.16096	3605	7026	-3421	10282	-6677	3256	0	
Gruy Petroleum Manage	Aid 24 State	1	30-015-22878	17	28	24	660FSL/1980FWL	32.81549	-104.13148	3705	6844	-3139	10740	-7035	3896		
Louis Dreyfus Natura	Rio Ocho 26 State	1	30-015-31184	17	28	26	1700 FS/880 FE	32.80356	-104.14083	3676	6828	-3152	10640	-6964	3812	0	
J.B. Jameson	Delhi B State	1		17	28	28	800 FS/800 FW	32.80001	-104.18642	3696	7084	-3388	10400	-6704	3316	-	
Stanolind	State AB	1		17	28	29	1980 FS/1980 FE	32.80314	-104.19543	3716	7096	-3380	10270	-6554	3174	0	
Pan American	State Gas	1V		17	28	30	1190 FS/1090 FE	32.80083	-104.20943	3634	6844	-3210	10090	-6456	3246	0	
Arco Permian	Dancer 32 State	1	30-015-28863	17	28	32	1728 FN/916 FE	32.79298	-104.19197	3711	7004	-3293	10350	-6639	3346	0	
Yates	Federal CH	2	30-015-20978	18	24	1	1980FN/1980FW	32.77919	-104.54356	3706	5266	-1560	8194	-4488	2928	0	
OXY USA	Oxy Woof State	1	30-015-31930	18	24	2	1980FS/660FW	32.77552	-104.56504	3704	5242	-1538	8194	-4490	2952	-	
Yates	Laney AGJ Federal	1	30-015-26091	18	24	11	1980FN/1980FW	32.76461	-104.56076	3718	5246	-1528	8208	-4490	2962	-	
Yates Petroleum	Spearman KQ Fed	1	30-015-22861	18	24	13	1980FS/1980FW	32.74633	-104.54357	3680	5326	-1646	8352	-4672	3026	+	
Yates Petroleum	Anderson CS State	2	30-015-23961	18	24	14	1650FS/1980FE	32.74542	-104.55647	3692	5300	-1608	8310	-4618	3010	+	
Concho Resources	Southern Cross 16 State	1	30-015-29776	18	24	16	1650FS/990FW	32.74554	-104.59841	3614	5198	-1584	8242	-4628	3044	+	
Yates	Desana Unit	1	30-015-26137	18	24	17	1980FN/1980FE	32.75000	-104.60809	3826	5212	-1386	8222	-4396	3010	-	

Concho Resources	Southern Cross 19 State	1	30-015-30896	18	24	19	1650FN/1300FE	32.73633	-104.62308	3863	5244	-1381	8230	-4367	2986	0	
Concho Resources	Southern Cross 20 State	1	30-015-30897	18	24	20	1200FS/1100FE	32.72971	-104.60519	3822	5234	-1412	8374	-4552	3140	+	
Concho Resources	Southern Cross 22 State	1	30-015-30898	18	24	22	1700FN/1100FE	32.73621	-104.57068	3746	5400	-1654	8510	-4764	3110	+	
Murchison O&G	Lincoln State	1	30-015-22447	18	24	24	2030FN/660FE	32.73528	-104.53490	3674	5462	-1788	8554	-4880	3092	+	
Mesa Petroleum	Fourmile Federal	1	30-015-23072	18	24	26	660FS/1980FE	32.71360	-104.55621	3712	5344	-1632	8634	-4922	3290	+	
Concho Resources	Southern Cross 27 State	1	30-015-32670	18	24	27	1980FN/1980FE	32.72102	-104.57342	3756	5304	-1548	8504	-4748	3200	0	
Estoril Production	Maralo State	1	30-015-21624	18	24	28	660FN/1980FW	32.72462	-104.59515	3808	5292	-1484	8420	-4612	3128	-	
Maddox Energy	State 32	1	30-015-22467	18	24	32	1980FS/660FE	32.70309	-104.60343	3744	5220	-1476	8518	-4774	3298	-	
Amoco	State GP Gas	1	30-015-22801	18	24	33	1980FN/1980FE	32.70664	-104.59057	3748	5440	-1692	8570	-4822	3130	0	
Gulf	Eddy 35 State	1	30-015-23044	18	24	35	1980FN/1980FE	32.70634	-104.55618	3713	5268	-1555	8752	-5039	3484	0	
Merit Energy	Johnson	1	30-015-20936-000	18	25	2	2080 FS/660 FE	32.77517	-104.44887	3468	5542	-2074	8438	-4970	2896	0	
Yates Petroleum	Murphy NW Federal	1	30-015-23506	18	25	3	1980FS/990FW	32.77519	-104.47818	3531	5498	-1967	8556	-5025	3058	+	
Yates Petroleum	Griffin JJ	1	30-015-22424	18	25	4	1650FN/1980FW	32.77995	-104.49221	3567	5448	-1881	8422	-4855	2974		
Yates Petroleum	Federal CX	1	30-015-20967	18	25	7	1980 FN/660 FE	32.76457	-104.51786	3615	5378	-1763	8358	-4743	2980	+	
Yates Petroleum	Federal CZ	1	30-015-21058	18	25	8	660 FN/1980 FE	32.76817	-104.50500	3595	5426	-1831	8462	-4867	3036	-	
Yates Petroleum	Federal AB	7	30-015-23646	18	25	9	1980FN/660FW	32.76451	-104.49368	3597	5444	-1847	8552	-4955	3108	-	
Coquina Oil	Clancy	1	30-015-20818	18	25	11	660 FS/1980 FE	32.75647	-104.45274	3471	5568	-2097	8612	-5141	3044	+	
Pennzoil	Vandiver	1	30-015-20250	18	25	13	1980FN/1980FW	32.74936	-104.43975	3473	5648	-2175	8706	-5233	3058	-	
Yates Petroleum	4 Dinkus GV State	1	30-015-22045	18	25	16	660FS/1980FE	32.74261	-104.48756	3566	5556	-1990	8784	-5218	3228	0	
Yates Petroleum	Gulf KC State	1	30-015-22728	18	25	18	660 FN/1980 FW	32.75360	-104.52634	3623	5350	-1727	8406	-4783	3056	+	
Gulf Oil	Eddy GK State	2	30-015-22345	18	25	19	2310 FN/1980 FW	32.73450	-104.52632	3657	5420	-1763	8550	-4893	3130	+	
Yates Petroleum	Federal AB	5	30-015-22423	18	25	21	1980FS/660FW	32.73170	-104.49591	3574	5522	-1948	8790	-5216	3268	+	
Yates Petroleum	Connor RR	1	30-015-23941	18	25	23	1915FS/2310FW	32.73110	-104.45615	3504	5610	-2106	8910	-5406	3300	0	
David Fasken	Yates Federal 25	1	30-015-20400	18	25	25	1490FNL/1650FWL	32.72171	-104.44103	3459	5700	-2241	8948	-5489	3248	0	
Morris Antweil	Rio	1	30-015-22175	18	25	29	1980FN/1980FE	32.72087	-104.50449	3596	5512	-1916	8782	-5186	3270	0	
Yates Petroleum	Penasco IW State	7	30-015-23463	18	25	31	1980 FS/660 FW	32.70279	-104.53044	3624	5452	-1828	8840	-5216	3388	0	
Scoggins & Cowgulch	State BI	1		18	25	33	1980 FN/1980 FW	32.70644	-104.49164	3592	5588	-1996	8960	-5368	3372	0	
Yates Petroleum	Gushwa	1	30-015-21002	18	25	35	1980 FN/660 FW	32.70583	-104.46140	3498	5660	-2162	9066	-5568	3406	0	
Yates Petroleum	Suburb AZS State	1	30-015-31906	18	25	36	660FNL/660FEL	32.70940	-104.43143	3478	5798	-2320	9158	-5680	3360	0	
Fasken Barbara	Higgins Trust	1	30-015-27970	18	26	1	990 FN/990 FW	32.78119	-104.34026	3302	5906	-2604	8926	-5624	3020	0	
WM. G. Ross	A.Q. Rogers	1	30-015-21571	18	26	3	660 FS/660 FE	32.77121	-104.36308	3334	5840	-2506	8914	-5580	3074	0	
Yates Petroleum	Box ACH	1	30-015-25249	18	26	4	1980 FS/660 FW	32.77480	-104.39304	3376	5726	-2350	8696	-5320	2970	0	
Yates	yates 6 Federal	2	30-015-22377	18	26	6	1980FN/1980FE	32.77867	-104.41891	3430	5662	-2232	8548	-5118	2886	0	
Yates Petroleum	Ferguson DY	1	30-015-21412	18	26	7	1980FN/660FE	32.76405	-104.41487	3438	5758	-2320	8776	-5338	3018	0	
David Fasken	Vandiver 7	1	30-015-20962	18	26	7	660 FS/660 FW	32.75676	-104.42715	3446	5684	-2238	8830	-5384	3146	0	
Maddox Energy	Torres	1	30-015-22178	18	26	9	990FS/1650FE	32.75761	-104.38348	3376	5868	-2492	9016	-5640	3148	0	
David Fasken	Roger 10	1	30-015-21182	18	26	10	1650 FS/660 FE	32.75938	-104.36307	3329	5870	-2541	8956	-5627	3086	0	
Felmont Oil	Atoka	2	30-015-21281	18	26	12	990FS/990FE	32.75749	-104.32944	3300	5972	-2672	9200	-5900	3228	0	
Standard of Texas	Everest	1		18	26	14	660 FS/1980 FW	32.74572	-104.35868	3343	6176	-2833	9160	-5817	2984	0	poor logs
Yates Petroleum	Am Marathon State	1		18	26	16	990FS/990FE	32.74282	-104.38172	3370	5910	-2540	8984	-5614	3074	0	
Great Western Drilling	Coats	1	30-015-33409	18	26	19	990FN/990FE	32.73745	-104.41551	3458	5764	-2306	8992	-5534	3228	0	
Yates Brothers	Bob Gushwa	1		18	26	21	1650FS/1650FE	32.73020	-104.38367	3387	6130	-2743	9130	-5743	3000	0	
Depco	Terry Evans	1	30-015-21609	18	26	24	1980FNL/1880FEL	32.73493	-104.33260	3302	6092	-2790	9354	-6052	3262	0	no logs @ depth
Ralph Nix	Melaine Battery 2	2	30-015-21076	18	26	26	990FS/1650FE	32.71400	-104.34912	3314	5982	-2668	9358	-6044	3376	0	
Yates Petroleum	Len Mayer	1	30-015-05926	18	26	28	990FN/990FW	32.72290	-104.39226	3435	5916	-2481	9172	-5737	3256	0	
Marathon	Ralph Nix	1	30-015-00256	18	26	29	1980 FS/1980 FE	32.71655	-104.40187	3433	5870	-2437	9164	-5731	3294	0	
Ohio Oil	Culpepper Unit	1		18	26	30	1650 FS/1650 FE	32.71568	-104.41784	3447	5810	-2363	9084	-5637	3274	0	
Yates Petroleum	Nix Curtis JF	1		18	26	32	990FN/990FW	32.70839	-104.40928	3429	5954	-2525	9190	-5761	3236	0	
Yates Petroleum	Northwestern Shores XR Federal	1	30-015-24600	18	26	36	660FNL/1980FEL	32.70947	-104.33241	3296	6154	-2858	9458	-6162	3304	0	
Marbob Energy	BPO State	1	30-015-31967	18	27	2	990FNL/990FWL	32.78019	-104.25391	3610	6594	-2984	9832	-6222	3238	0	
William Hudson	Hudson Hondo	1		18	27	4	2190 FN/1650 FE	32.77687	-104.27969	3598	6540	-2942	9680	-6082	3140	0	
SDX Resources	Chalk Bluff Draw Federal	1	30-015-00789-000	18	27	5	2055 FS/1980 FW	32.77495	-104.30211	3512	6318	-2806	9500	-5988	3182	-	no logs
Amoco	Hondo B Federal	1	30-015-21114	18	27	8	2310FS/660FW	32.76106	-104.30640	3405	6286	-2881	9354	-5949	3068	0	
BP America	Horsetail Gas Federal	1	30-015-32556	18	27	10	710FSL/660FEL	32.75643	-104.25925	3531	6400	-2869	9950	-6419	3550	0	
Navajo Refining	Navajo Refining	WD2	30-015-20894	18	27	12	1980FN/660FW	32.76334	-104.23789	3623	6646	-3023	10164	-6541	3518		
Yates Petroleum	Beauregard ANM State	1	30-015-27448	18	27	14	1980FS/660FW	32.74529	-104.25505	3493	6360	-2867	10014	-6521	3654	-	
Humble Oil & Refining	Chalk Bluff Draw Unit C	1	30-015-00914	18	27	17	1980FN/1980FE	32.74928	-104.29805	3437	6366	-2929	9492	-6055	3126	-	
Humble Oil & Refining	Kathleen Steckel	1	30-015-00924	18	27	19	660FNL/1980FEL	32.73849	-104.31530	3303	6380	-3077	9440	-6137	3060	0	no logs
Mewbourne Oil	Federal S	1	30-015-26432	18	27	21	710FN/660FE	32.73827	-104.27650	3401	6462	-3061	9728	-6327	3266	0	
Gulf	Gulf et al Eddy State	1		18	27	25	1980FSL/2009FWL	32.71594	-104.23363	3573	7696	-4123	10312	-6739	2616	-	
Yates Petroleum	Chalk AKH Federal	2	30-015-27034	18	27	27	660FN/1330FE	32.72380	-104.26162	3475	7562	-4087	10108	-6633	2546	+	
Yates Petroleum	Rio Pecos GB	1	30-015-21889	18	27	29	660FN/1980FW	32.72399	-104.30251	3322	6354	-3032	9524	-6202	3170	0	
Yates Petroleum	Compromise AEJ Federal	1	30-015-25665	18	27	30	1980FNL/800FEL	32.72036	-104.31157	3296	6622	-3326	9532	-6236	2910	0	
Tenneco	McMillan JN33	1	30-015-23654	18	27	33	760FN/2040FW	32.70933	-104.28530	3399	7138	-3739	9798	-6399	2660	0	
Morexco	Apex State	1	30-015-22872	18	27	35	1980FS/1980FW	32.70185	-104.25075	3519	7950	-4431	10186	-6667	2236	-	
Amoco Production Co.	Empire south deep Unit	10	30-015-21871	18	28	1	1980FNL/1980FEL	32.77888	-104.12750	3687	7610	-3923	10934	-7247	3324	0	
Hondo Oil & Gas	Featherstone state com	1	30-015-24005	18	28	3	1680FSL/660FEL	32.77383	-104.15695	3657	7384	-3727	10680	-7023	3296	0	
Phillips	Illinois Camp A	1	30-015-24485	18	28	5	1980FN/990FW	32.77757	-104.20257	3672	7524	-3852	10194	-6522	2670	0	
Duke Energy	Duke AGI	WI-1	30-015-32324	18	28	7	1232FS/1927FE	32.75739	-104.21193	3629	7124	-3495	10244	-6615	3120	0	
SDX Resources	Dunn "B" federal	37	30-015-23225	18	28	10	1550FNL/660FWL	32.76473	-104.16962	3661	7420	-3759	10538	-6877	3118	0	
Amoco	Empire South Deep Unit	20	30-015-22668	18	28	12	1980FN/2200FE	32.76421	-104.12833	3640	7854	-4214	10956	-7316	3102	0	
Harvey Yates	Travis Deep Unit	3	30-015-22355	18	28	13	660FNL/1980FEL	32.75345	-104.12760	3654	8280	-4626	11024	-7370	2744	+	

Mewbourne Oil	Illinois Camp 17 State	3	30-015-32009	18	28	17	870FS/660FW	32.74215	-104.20345	3625	7880	-4255	10500	-6875	2620	0	
Louis Dreyfus Natural Ga	Artesia 21 State	2	30-015-32193	18	28	21	990FN/660FE	32.73738	-104.17397	3612	7528	-3916	10712	-7100	3184	0	
Hondo Oil & Gas	Turkey Town State	1	30-015-24228	18	28	23	660FSL/1980FWL	32.72757	-104.14845	3518	8700	-5182	10838	-7320	2138	0	
Anadarko	Turkey Tract State	1	30-015-22275	18	28	25	1980FS/660FE	32.71696	-104.12359	3483	8722	-5239	10966	-7483	2244	-	
Devon	Hondo Sinclair State	1	30-015-23703	18	28	28	1980FN/1980FE	32.72017	-104.17839	3550	8242	-4692	10708	-7158	2466	0	
Yates	Illinois Camp NN State	1	30-015-23346	18	28	30	660FS/1980FW	32.71237	-104.21671	3558	7896	-4338	10564	-7006	2668	-	
Yates	HY State GH	1	30-015-21860	18	28	31	1980FS/1980FW	32.70160	-104.21669	3565	7962	-4397	10576	-7011	2614	-	
Marathon	James Buchanan 33 State	1	30-015-29890	18	28	33	2000FS/660FE	32.70220	-104.17431	3558	8604	-5046	10952	-7394	2348	+	
Anadarko Pet	New Mexico State "AA"	1	30-015-22698	18	28	35	1980FNL/1980FWI	32.70582	-104.14877	3497	8770	-5273	11083	-7586	2313	0	
Yates	Federal CW	1	30-015-20968	19	24	1	720FS/1830FW	32.68465	-104.54372	3691	5406	-1715	9108	-5417	3702	0	
Amoco	State IL	1	30-015-23349	19	24	3	1980FN/1980FE	32.69209	-104.57339	3771	5334	-1563	8716	-4945	3382	0	
Superior	Sullivan Federal	1	30-015-20352	19	24	5	660FS/660FW	32.68483	-104.61661	3834	5208	-1374	8538	-4704	3330	-	
Exxon	New Mexico DB State	1	30-015-23682	19	24	7	1980FN/1980FW	32.67725	-104.62961	3837	5130	-1293	8400	-4563	3270	0	
Yates	Rancherita AMH State	1	30-015-27210	19	24	8	660FS/1980FW	32.67020	-104.61220	3781	5194	-1413	8534	-4753	3340	-	
Yates	davis NC	1	30-015-23540	19	24	11	1980FS/660FE	32.67361	-104.55182	3653	5192	-1539	8968	-5315	3776	-	
Yates	Allison CQ Fed	5	30-015-23145	19	24	13	660FN/1980FW	32.66631	-104.54326	3629	5416	-1787	9054	-5425	3638	0	
Yates	Routh NU Deep	2	30-015-23585	19	24	14	660FN/1980FE	32.66636	-104.55613	3651	5342	-1691	8960	-5309	3618	0	
Yates	Allison CQ Fed	9	30-015-24133	19	24	15	990FN/1300FW	32.66563	-104.57997	3703	5256	-1553	8878	-5175	3622	0	
Exxon	New Mexico DE State	1	30-015-24122	19	24	19	660FN/1980FW	32.65150	-104.62971	3815	5132	-1317	8506	-4691	3374	+	
Yates	Emma QE	2	30-015-24096	19	24	21	660FS/1980FE	32.64104	-104.59048	3730	5280	-1550	8902	-5172	3622	+	
Yates	Allison CQ Fed.	7	30-015-23778	19	24	23	1980 FN/660 FW	32.64816	-104.56477	3662	5316	-1654	8910	-5248	3594	0	
Yates	Parish IV	2	30-015-2618	19	24	26	1980FN/1980FW	32.63358	-104.56036	3657	5358	-1701	9120	-5463	3762	+	
yates	Amoco QT Federal	1	30-015-23591	19	24	29	1980FN/1980FW	32.63375	-104.61203	3777	5220	-1443	8810	-5033	3590	0	
Yates	Siegiest JS State	1	30-015-22563	19	24	30	660FN/1980FW	32.63721	-104.62936	3826	5126	-1300	8590	-4764	3464	-	
Yates	Oakason NV Federal	3	30-015-24095	19	24	34	2030FN/1650FE	32.61896	-104.57231	3732	5362	-1630	9124	-5392	3762	-	
Yates	State CO	2	30-015-22383	19	24	36	1850FN/1980FE	32.61936	-104.53899	3622	5442	-1820	9346	-5724	3904	+	
Yates	Rio Penasco KD	2	30-015-23353	19	25	2	1680FNL/1980FWL	32.69244	-104.45711	3461	6790	-3329	9250	-5789	2460	0	
Yates	Ottawa AOW Federal	2	30-015-28753	19	25	3	660FS/660FW	32.68446	-104.47851	3522	6860	-3338				+	
Anadarko	Arco 4 Matlock	1	30-015-20593	19	25	4	1980FSL/1980FEL	32.68808	-104.48737	3558	6870	-3312	9130	-5572	2260	+	
Yates	Mobil CI Federal	11	30-015-23335	19	25	6	2030FSL/990FWL	32.68824	-104.52932	3663	5484	-1821	8932	-5269	3448	-	
Yates	Roy AET	WD-3	30-015-26562	19	25	7	810FSL/660FEL	32.67021	-104.51724	3571	6450	-2879	9066	-5495	2616	0	
Yates	Roy AET	1	30-015-25905	19	25	8	660FS/1980FW	32.66983	-104.50866	3573	6788	-3215				+	
David Fasken	Johnston 9 Federal	1	30-015-20677	19	25	9	1980FSL/1980FWL	32.67345	-104.49140	3551	6472	-2921	9182	-5631	2710	+	
Yates	Arco 10 federal	2	30-015-20692	19	25	10	1980FN/1980FE	32.67719	-104.47003	3498	6550	-3052				+	
Nearburg	Rose 12A	1	30-015-25991	19	25	12	990FN/990FE	32.67936	-104.43243	3419	6200	-2781	9250			0	
Yates	Cotton MX Federal	1	30-015-23315	19	25	14	810FNL/2180FWL	32.66579	-104.45654	3445	6456	-3011	9338	-5893	2882	+	
Yates	Jenny	1	30-015-26469	19	25	17	1750FNL/660FWL	32.66318	-104.51302	3358	6546	-3188	9130	-5772	2584	+	
Amoco	Lodewick A	1	30-015-23960	19	25	19	660FN/1980FW	32.65184	-104.52612	3601	6426	-2825				+	
Morris R Antweil	B&B	1	30-015-22466	19	25	22	1980FNL/1980FEL	32.64785	-104.47021	3468	6158	-2690	9364	-5896	3206	+	
Nearburg	Parino	1	30-015-23049	19	25	23	1980FS/660FE	32.64406	-104.44861	3432	6410	-2978	9600	-6168	3190	+	
Nearburg	South Boyd	1	30-015-24568	19	25	27	1980FN/1980FW	32.63339	-104.47397	3468	5994	-2526	9512	-6044	3518	+	
Conoco	Dagger Draw	8	30-015-25833	19	25	30	1980FS/1980FE	32.62976	-104.52166	3565	5872	-2307				+	
Monsanto	Albert State	1	30-015-22187	19	25	32	1980FNL/1980FWL	32.61878	-104.50899	3529	6044	-2515	9480	-5951	3436	-	
Hilliard Oil & Gas	Gulf Federal	1	30-015-21066	19	25	35	1980FN/1980FW	32.61847	-104.45699	3520	6850	-3330	9794	-6274	2944	0	
Marbob	E.G. Nix	1	30-015-22067	19	26	2	660FNL/1980FEL	32.69493	-104.35014	3316	7164	-3848	9486	-6170	2322	0	
Nearburg Production	Fanning	WD1	30-015-20920	19	26	4	1980FS/1980FW	32.68763	-104.38890	3370	7120	-3750	9366	-5996	2246	-	
Dorchester Exploration	Morrison	1	30-015-22250	19	26	5	1980FSL/660FWL	32.68752	-104.41020	3377	6970	-3593	9236	-5859	2266	0	
Nearburg Production	Howe 6L	1	30-015-26270	19	26	6	1980FSL/660FWL	32.68750	-104.42712	3406	6824	-3418	9248	-5842	2424	0	
Chama Petroleum	Crusader Rabbit	1	30-015-22599	19	26	8	660FN/1980FW	32.68029	-104.40582	3390	6510	-3120	9486	-6096	2976	0	
Samedan	Nix	1	30-015-21329	19	26	9	660FN/2310FE	32.68038	-104.38563	3349	6718	-3369	9416	-6067	2698	0	
Robert Enfield	North lake McMillan	1	30-015-22663	19	26	12	1980FSL/1980FEL	32.67284	-104.33241	3304	7292	-3988	9808	-6504	2516	-	
American Public Energy	Spencer Trust	1	30-015-23593	19	26	15	1980FSL/1980FWL	32.65824	-104.37132	3350	7296	-3946	9770	-6420	2474	0	
Ernest A Hanson	Santa Fe land	1		19	26	17	660FN/1980FW	32.66555	-104.40569	3396	6994	-3598	9700	-6304	2706	-	
Yates	Lakewood State	1	30-015-22233	19	26	30	1980FN/1980FW	32.63302	-104.42293	3436	6870	-3434	9680	-6244	2810	+	
Gulf	Ben F Pearman Jr	1		19	26	32	1980FSL/1980FWL	32.61470	-104.40564	3316	7036	-3720	9682	-6366	2646	0	
Southland Royalty	Stewart State	1	30-015-22273	19	27	1	660FN/1980FE	32.69431	-104.22955	3548	8042	-4494	10420	-6872	2378	0	
Hanagan	East McMillan	1	30-015-20609	19	27	3	1980FSL/1980FWL	32.68768	-104.26812	3434	7770	-4336	10170	-6736	2400	-	no log at depth
Yates	Eastern Shore XM Federal	1	30-015-24534	19	27	5	660FS/2310FE	32.68402	-104.29942	3294	7434	-4140	9852	-6558	2418	+	
Maralo	Federal 6	1	30-015-26228	19	27	6	1980FNL/1980FWL	32.69136	-104.31967	3294	7264	-3970	9692	-6398	2428	-	
Yates Petroleum	Eastern Shore QW Federal	1	30-015-23862	19	27	8	1623FSL/1692FEL	32.67197	-104.29735	3348	7480	-4132	9960	-6612	2480	-	no log at depth
Yates Petroleum	Bluffside WF Federal	1	30-015-24348	19	27	9	1980FNL/660FWL	32.67675	-104.28973	3339	7788	-4449	10034	-6695	2246	0	
Southland Royalty	JEB Stuart 13	1	30-015-23133	19	27	13	1980FS/1980FE	32.65832	-104.22989	3504	8328	-4824	10870	-7366	2542	0	
Yates Petroleum	Williams Hollow PN State	1	30-015-23657	19	27	14	1980FSL/1980FWL	32.65852	-104.25086	3470	8114	-4644	10554	-7084	2440	-	
Yates Petroleum	Amigo WI State	1	30-015-24422	19	27	16	2310FS/660FW	32.65926	-104.28975	3379	7668	-4289	10130	-6751	2462	0	
Yates Petroleum	Eastern Shore OV Federal	1	30-015-23678	19	27	17	660FN/1980FE	32.6657	-104.29829	3364	7664	-4300	10126	-6762	2462	0	
Southland Royalty	Pecos River 20	1	30-015-23090	19	27	20	1980FSL/1980FEL	32.64391	-104.29836	3404	7738	-4334	10224	-6820	2486	+	
Southland Royalty	Pecos River 21 Federal	1	30-015-23558	19	27	21	1980FS/2030FW	32.64382	-104.28533	3441	7888	-4447	10214	-6773	2326	0	
Southland Royalty	State G	1	30-015-22955	19	27	24	1980FNL/660FWL	32.64756	-104.23828	3475	8374	-4899	10782	-7307	2408	0	
Mewbourne Oil	Angel Ranch 26 State	1	30-015-27049	19	27	26	990FN/990FE	32.63564	-104.24364	3521	8474	-4953	10904	-7383	2430	0	
Yates Petroleum	Parrott Federal	2	30-015-33345	19	27	29	1600FSL/660FEL	32.62838	-104.29411	3426	7890	-4464	10370	-6944	2480	+	
Pogo	Pecos 32 State	1	30-015-32471	19	27	32	1980FN/990FE	32.61855	-104.29597	3438	8032	-4594	10564	-7126	2532	0	
Bennett & Ryan	Pecos River Federal	1	30-015-21977	19	27	34	660FN/1980FW	32.62188	-104.26841	3391	8220	-4829	10696	-7305	2476	-	

Gulf	Eddy GM State	1	30-015-22366	19	27	36	660FSL/1980FEL	32.61138	-104.23122	3415	8634	-5219	11050	-7635	2416	0	
Bass Enterprises	Merchant State	1	30-015-22941	19	28	1	1980FNL/660FEL	32.69169	-104.12358	3403	8888	-5485	11252	-7849	2364	0	
Stanolind	State AI	1		19	28	3	1650FNL/1650FEL	32.69231	-104.16039	3531	8834	-5303	11038	-7507	2204	-	
Hanagan	Millman Deep Unit	1	30-015-20532	19	28	4	660FN/1924FE	32.69481	-104.17832	3550	8640	-5090	10902	-7352	2262	-	
Marbob	State HU	1	30-015-22146	19	28	7	660FS/2080FW	32.66922	-104.21657	3528	8614	-5086	11238	-7710	2624	-	
Yates	North Millman	2	30-015-23409	19	28	8	1980FN/1980FE	32.67685	-104.19484	3558	8730	-5172	11040	-7482	2310	-	
Depco	DHY State B	1	30-015-21971	19	28	11	1980FS/990FW	32.67349	-104.15145	3489	8970	-5481	11228	-7739	2258	-	
Atlantic Richfield	State BP	1	30-015-22089	19	28	14	810FS/1980FE	32.65548	-104.14470	3418	9044	-5626	11280	-7862	2236	0	
Depco	DHY State A	1	30-015-21711	19	28	15	1980FS/1650FE	32.65863	-104.16028	3467	8868	-5401	11232	-7765	2364	0	
Yates	Millman HD State	2	30-015-22249	19	28	17	660FN/1980FE	32.66587	-104.19483	3540	8850	-5310	11134	-7594	2284	0	
Southland Royalty	State 19	2	30-015-22625	19	28	19	860FSL/2057FWL	32.64054	-104.21684	3508	8670	-5162	11130	-7622	2460	0	
SDX Resources	East Millman Unit	202	30-015-22188	19	28	22	1980FN/990FE	32.64775	-104.15831	3395	9036	-5641	11252	-7857	2216	+	
Depco	DHY State	1	30-015-21638	19	28	23	1980FN/1980FW	32.64779	-104.14866	3402	9042	-5640	11500	-8098	2458	0	
Bennett & Ryan	Exxon State	1	30-015-21585	19	28	25	660FS/1980FW	32.62616	-104.13176	3338	9270	-5932	11286	-7948	2016	+	
Yates	Hubble 28 State	1	30-015-30782	19	28	28	1980FN/990FW	32.63304	-104.18539	3398	9070	-5672	11134	-7736	2064	+	
Gulf	Pacheco federal	3	30-015-22612	19	28	31	2280FN/660FW	32.61791	-104.22207	3405	8696	-5291	11008	-7603	2312	-	
Southland Royalty	State A-32	1	30-015-23345	19	28	32	1980FSL/1980FEL	32.6152	-104.19627	3379	8912	-5533	11180	-7801	2268	0	
Dorchester Exploration	DWU Federal	2	30-015-20875	19	28	35	1980FN/1980FW	32.6188	-104.14942	3318	9170	-5852	11300	-7982	2130		
Yates	Foster FF	1	30-015-21705	20	24	1	1980FSL/1980FEL	32.60073	-104.53914	3598	5368	-1770	9420	-5822	4052	+	
Yates	Cacti AGB State	1	30-015-26047	20	24	2	1980FSL/2230FEL	32.60076	-104.55688	3648	5474	-1826	9380	-5732	3906	0	
Yates	Mimosa AHS Fed	WD-1	30-015-26449	20	24	4	1980FS/810FE	32.60085	-104.58707	3764	5350	-1586	8972	-5208	3622	0	
Yates	Gulf AGT Federal	1	30-015-20344	20	24	6	1980FNL/1980FWL	32.60422	-104.62903	3940	5138	-1198	8996	-5056	3858	0	
Yates	Judith AIJ Federal	1	30-015-26632	20	24	9	660FSL/660FEL	32.58252	-104.58661	3758	5396	-1638	9270	-5512	3874	+	
Yates	Saguaro AGS Federal	1	30-015-26206	20	24	11	1980FS/660FW	32.58607	-104.56535	3654	5406	-1752	9390	-5736	3984	+	
Yates	Cenza AGZ	2	30-015-26466	20	24	12	660FSL/725FWL	32.58248	-104.54742	3617	5642	-2025	9392	-5775	3750	+	
Yates	Saguaro AGS Federal	4	30-015-26420	20	24	14	1980FSL/1980FEL	32.57148	-104.5564	3630	5480	-1850	9536	-5906	4056	+	
Yates	Algerita AHR State	1	30-015-26383	20	24	16	1980FNL/660FEL	32.57527	-104.5866	3732	5306	-1574	9158	-5426	3852	+	
Yates	Albert AJH	1	30-015-26720	20	24	21	660FN/660FE	32.56436	-104.58662	3733	4854	-1121	9040	-5307	4186	0	
Yates	Carl YB	1	30-015-26138	20	24	22	1980FSL/660FEL	32.5569	-104.56949	3680	5452	-1772	9330	-5650	3878	+	
McKay	Charolette Mckay federal	3	30-015-21561	20	24	25	660FNL/1980FWL	32.54963	-104.5438	3625	6404	-2779	9428	-5803	3024	-	
Yates	Saguaro AGS Federal	10	30-015-26852	20	24	26	660FN/1980FW	32.54976	-104.5609	3679	5760	-2081	9430	-5751	3670	+	
Tesoro Petroleum	Huber Federal 29	1	30-015-20943	20	24	29	2080FSL/1980FEL	32.54293	-104.60768	3835	6490	-2655	9100	-5265	2610	0	
Inexco	Long Box	1	30-015-22624	20	24	30	1980FN/660FE	32.54625	-104.62082	3910	6700	-2790	9190	-5280	2490	0	
Yates	Avenger AVG State	1	30-015-21423	20	24	32	1980FS/1980FW	32.52761	-104.6123	3873	5150	-1277	9090	-5217	3940	+	
yates	Diamond AKH Fed	1H	30-015-27086	20	24	34	660FS/2080FW	32.5241	-104.57752	3742	5796	-2054				+	
Marathon	Indian Hills State	1	30-015-22448	20	24	36	1650FNL/1980FEL	32.5323	-104.53906	3617	6366	-2749	9536	-5919	3170	-	
Santa Fe Exploration	Exxon State	1	30-015-24091	20	25	2	1980FSL/660FWL	32.60049	-104.46149	3440	6914	-3474	9560	-6120	2646	0	
Nearburg	Huber federal	2	30-015-24261	20	25	3	1650FNL/1980FEL	32.60498	-104.47013	3477	6810	-3333	9624	-6147	2814	0	
Nearburg	Holston	WD-1	30-015-21141	20	25	4	660FNL/1980FEL	32.60774	-104.48744	3503	6528	-3025	9440	-5937	2912	0	
Roger C Hanks	Foster	WD-1		20	25	5	660FNL/660FWL	32.60782	-104.51326	3547	6052	-2505	9304	-5757	3252	0	
Monsanto	Dagger Draw Unit	1		20	25	6	660FS/1980FE	32.59694	-104.5219	3550	5904	-2354	9412	-5862	3508	0	
Monsanto	Dagger Draw	2	30-015-21271	20	25	8	1980FSL/1980FWL	32.58606	-104.50886	3528	6540	-3012	9518	-5990	2978	-	
Amoco	Rio Siete	1	30-015-22729	20	25	11	1980FS/2310FE	32.58577	-104.45412	3378	6970	-3592	9660	-6282	2690	0	
Nearburg	Genecco 14D	1	30-015-24141	20	25	14	660FNL/660FWL	32.57855	-104.46157	3433	6900	-3467	9710	-6277	2810	0	
Phillips Petroleum Co.	Royal	1A		20	25	16	1980FSL/1965FWL	32.5715	-104.49183	3490	6864	-3374	9584	-6094	2720	0	
Yates	Moore FQ	1	30-015-21755	20	25	19	1980FNL/1980FWL	32.56054	-104.52622	3579	6610	-3031	9700	-6121	3090	0	
David Fasken	Cemetary Federal	1	30-015-21342	20	25	21	1980FSL/660FWL	32.55692	-104.49594	3505	6606	-3101	9574	-6069	2968	0	
Southern Union	Exxon Federal	2	30-015-22546	20	25	23	660FS/1980FE	32.55327	-104.45315	3509	7250	-3741	9962	-6453	2712	0	
Southern Union	Exxon Federal A	1	30-015-22244	20	25	25	880FSL/1880FWL	32.5393	-104.44079	3714	7524	-3810	10270	-6556	2746	0	
Shell	Federal A	1		20	25	27	1980FSL/1980FEL	32.54249	-104.47028	3614	7090	-3476	9864	-6250	2774	-	
David Fasken	Howell 29	1	30-015-21140	20	25	29	1980FN/2310FE	32.54605	-104.50552	3557	6600	-3043	9520	-5963	2920	0	rec gas on DST
Read & Stevens	Allirish	1	30-015-21321	20	25	30	660FSL/990FEL	32.53886	-104.51836	3600	6800	-3200	9616	-6016	2816	-	no logs
Gulf	Jones Federal	2	30-015-22753	20	25	33	660FSL/1980FWL	32.52429	-104.49162	3679	7014	-3335	9774	-6095	2760	0	
Echo Production	Stiletto 34 Federal	1	30-015-33460	20	25	34	1310FN/660FW	32.53338	-104.47887	3666	6900	-3234	9870	-6204	2970	0	
Llano	South Lakewood	1X	30-015-21900	20	26	3	1980FN/840FW	32.60389	-104.37526	3271	7430	-4159	9940	-6669	2510	0	
Southern Union	Moutray	1	30-015-21283	20	26	5	1980FN/660FE	32.60378	-104.39721	3283	7228	-3945	9910	-6627	2682	0	
Yates	Pecos River Deep Unit	4		20	26	11	1980FS/1650FE	32.58576	-104.35111	3290	7736	-4446	10124	-6834	2388	0	
Llano Inc	South Willow Draw A	1	30-015-21979	20	26	17	2310FN/1980FE	32.57399	-104.40181	3271	7382	-4111	10016	-6745	2634	-	
Maddox Energy	South Willow Draw	1	30-015-21883	20	26	18	1980FS/990FE	32.57131	-104.41576	3313	7258	-3945	9942	-6629	2684	-	
Pan American	Adams Bend	1		20	26	23	1980FN/1980FW	32.5605	-104.35642	3290	7834	-4544	10364	-7074	2530	0	
Marbob	State CJ	1	30-015-20096	20	26	24	1655FNL/1650FEL	32.5614	-104.334	3309	7964	-4655	10416	-7107	2452	0	
Skelly	New Mexico D	1		20	26	25	1650FNL/1650FWL	32.54683	-104.34061	3308	7908	-4600	10382	-7074	2474	0	
Maralo	Bubbling Springs Federal	WD1	30-015-20992	20	26	26	1980FNL/1980FWL	32.54588	-104.35583	3280	7852	-4572	10356	-7076	2504	+	
Jake L Hamon	State 32	1	30-015-23660	20	26	32	2080FNL/1980FEL	32.53127	-104.40186	3321	7530	-4209	10208	-6887	2678	-	
Jake L Hamon	Federal 33	1	30-015-23379	20	26	33	1980FSL/660FEL	32.52778	-104.38038	3296	7630	-4334	10392	-7096	2762	-	
Conoco	Federal 34	1	30-015-22738	20	26	34	960FSL/1980FWL	32.52501	-104.37186	3258	7764	-4506	10356	-7098	2592	-	
John H Trigg	Federal TY	3	30-015-22557	20	27	3	1980FNL/2230FWL	32.60399	-104.26943	3357	8276	-4919	10740	-7383	2464	+	
Harvey Yates	Yates Federal Deep	1		20	27	5	990FN/990FW	32.60678	-104.30785	3395	7968	-4573	10410	-7015	2442	-	
Harvey Yates	Yates Turner 7 Federal Deep	1	30-015-31255	20	27	7	1980FN/660FW	32.58968	-104.32652	3339	7866	-4527	10368	-7029	2502	0	
David Fasken	Amarillo Gulf 11	1	30-015-20876	20	27	11	1980FNL/660FEL	32.58987	-104.24406	3412	8664	-5252	11056	-7644	2392	-	
Boyd Operating	Murphy Federal	1	30-015-22781	20	27	12	660FSL/1980FEL	32.58253	-104.23133	3332	8650	-5318	11028	-7696	2378	0	
Texas Oil & Gas Corp.	McMillan Federal	1	30-015-22384	20	27	14	2080 FSL/1980FEL	32.57181	-104.24887	3334	8734	-5400	11130	-7796	2396	-	

Meadco Properies	Lario Federal	1	30-015-21310	20	27	17	1650FN/2160FE	32.57637	-104.30121	3345	8098	-4753	10652	-7307	2554	-		
Lario Oil & Gas	Superior Federal	1	30-015-20750	20	27	20	1650FNL/1650FWL	32.56166	-104.30605	3265	8106	-4841	10580	-7315	2474	0		
Penroc Oil Corp.	Allied A	1	30-015-21122	20	27	22	660 FSL/1980FWL	32.55317	-104.27052	3259	8540	-5281	10962	-7703	2422	0		
Morris Antweil	Muy Macho	1	30-015-22901	20	27	24	2080 FSL/760FWL	32.55696	-104.24005	3365	8986	-5621	11318	-7953	2332	0		
Gulf	Eddy FT State	2	30-015-22164	20	27	26	810 FNL/2180FEL	32.54905	-104.24959	3372	8880	-5508	11312	-7940	2432	0		
Moralco	Hanson Federal	2	30-015-21489	20	27	28	660 FSL/1650FEL	32.53871	-104.28245	3223	8544	-5321	10952	-7729	2408	0		
Hanagan	Mandy	1		20	27	30	1980 FSL/1980FEL	32.54242	-104.31805	3243	8144	-4901	10574	-7331	2430	0		
Monsanto	Coquina Federal	1	30-015-21500	20	27	31	1980 FSL/1980FEL	32.52772	-104.31792	3243	8184	-4941	10728	-7485	2544	-		
Maralo	Hanson Federal	1		20	27	34	660 FSL/1980FWL	32.52396	-104.27068	3207	8594	-5387	11050	-7843	2456	+		
Fasken	Maralo Federal	1	30-015-23302	20	27	35	1980 FSL/1980FEL	32.52762	-104.24926	3243	8756	-5513	11194	-7951	2438	-		
Yates Petroleum Corp.	Antongiovanni MJ Fed	1	30-015-23180	20	28	1	660 FNL/1980FWL	32.60774	-104.1321	3299	9272	-5973	11458	-8159	2186	0		
Cities Service	Government S	1	30-015-20932	20	28	3	1980FN/660FE	32.60431	-104.15823	3300	9104	-5804	11226	-7926	2122	0		
Penroc Oil Corp.	Wright Federal	1	30-015-21580	20	28	6	660FSL/1980FEL	32.59691	-104.21444	3339	8754	-5415	11096	-7757	2342	0		
Cities Service	Government AB	4	30-015-22019	20	28	9	2105 FSL/760FWL	32.58706	-104.18815	3301	9050	-5749	11224	-7923	2174	0		
OXY USA	Government AB	5	30-015-26248	20	28	11	1980 FNL/660FWL	32.58973	-104.15374	3280	9176	-5896	11262	-7982	2086	0		
OXY USA	Government NBFD	1	30-015-28841	20	28	11	660 FSL/330FWL	32.58241	-104.15459	3283	9218	-5935	11310	-8027	2092	0		
Yates	Maralo HL Federal	1	30-015-22074	20	28	12	1980 FSL/660FEL	32.58615	-104.12392	3279	9238	-5959	11550	-8271	2312	0		
OXY USA	Government AC	2	30-015-21514	20	28	13	1800FN/1980FW	32.57558	-104.13267	3269	9288	-6019	11470	-8201	2182	0		
Cities Service	Government AC	1	30-015-21432	20	28	15	660FSL/1980FWL	32.56814	-104.16717	3257	9210	-5953	11440	-8183	2230	0		
Cities Service	State CW	1	30-015-21902	20	28	19	1980 FNL/1980FWL	32.56039	-104.21901	3335	8918	-5583	11316	-7981	2398	0		
Yates	Stonewall DD	1	30-015-20892	20	28	20	660 FSL/1980FWL	32.5534	-104.20194	3265	8966	-5701	11318	-8053	2352	0		
Cities Service	Government U	1	30-015-21020	20	28	22	1980 FNL/1980FEL	32.56086	-104.16219	3249	9224	-5975	11432	-8183	2208	0		
Liberty O & G	Doris Federal	1	30-015-24208	20	28	26	1980 FSL/1980FEL	32.54224	-104.14555	3281	9376	-6095	11576	-8295	2200	0		
Monsanto	Burton Flat Unit	8	30-015-20959	20	28	27	660 FSL/1980FEL	32.53846	-104.16253	3236	9154	-5918	11340	-8104	2186	0		
Yates Petroleum Corp.	Stonewall EP State Com	1	30-015-21578	20	28	30	1980 FNL/1980FWL	32.54588	-104.21897	3300	9054	-5754	11360	-8060	2306	0		
Monsanto	Burton Flat	4	30-015-20835	20	28	34	660 FSL/18980FWL	32.52399	-104.16712	3210	9010	-5800	11440	-8230	2430	0		
Collins & Ware	AE 36 State	1	30-015-27005	20	28	36	2180 FNL/660FWL	32.53084	-104.13701	3225	9336	-6111	11670	-8445	2334	0		